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and
The Foundry Trades' Equipment and Supplies Association

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Self-Sufficing Industries

The personal experience of Germany which the British visitors recently had makes news from that country particularly interesting. There was noticed even in foundry circles a disposition to avoid the use of imported material as far as possible, and this lends colour to the announcement of the so-called four-year plan to make Germany independent of imported raw materials. It is well known that such materials can only be purchased with the foreign currencies derived from exports, and that these are lacking in the volume required. Certain basic raw materials affect all manufacturers, directly or indirectly, and some that come to mind are petrol, rubber and textiles, all normally having a natural origin. There is only one way in which substitutes for such materials can be made available, and that is by large-scale and intensive research, which Germany is better fitted to undertake than this country on account of her greater reserves of scientific man-power and her greater willingness to spend money on it, although nobody would admit the greater possibility of her success compared with this country, if the same conditions existed. At present, however, substitutes are apt to be more expensive than the natural materials; synthetic rubber is a commercial product costing several times the price of the natural material. Synthetic petrol produced from coal is commercially practicable, but only economic by a remission of tax designed to encourage production to ensure the existence of the necessary plant in time of emergency, whilst the production of synthetic textiles resembling wool or cotton is a curiosity rather than a practicable proposition.

The moral of the situation is that a return to more free trading conditions would probably do more to enable all countries to get natural raw materials than purely internal measures, although we must not underrate the possibilities of investigation, which first aims at doing something new before it can make large scale manufacture profitable. So far as the founding industry is concerned, nothing can replace the raw material of the blast furnace, and, speaking generally, the raw materials required are found in every industrial country. Indirectly, however, the industry in any country could be gravely handicapped by a limitation of raw material imports, and in certain particulars could be directly affected very severely. Thus, many foundry managers would scarcely like to forego using certain special imported sands, refractory materials, clays or plumbago, while universally used materials such as linseed and other drying oils come to mind. Such a plan, in fact, takes us a little further into the realms of artificiality and make-believe, of divorce from economic realities, into which Europe has been steadily moving.

Classification of Scrap

It came as a shock to us when we learnt that the United States Department of Commerce had defined and classified no less than seventy-five types of iron and steel scrap. This work has been done through the National Bureau of Standards, and it has been deemed wise to incorporate a standardised contract form for the purchase of scrap. Curiously enough on this form there is no reference to the various definitions established, and we see no reason why the buyer should not insert his own specification. For instance, the standard specification (No. 58) for No. 1 machinery cupola scrap reads:—"Clean machinery cast-iron scrap must be cupola size, not over 24 in. by 30 in. in dimensions and no piece to weigh over 150 lbs." There is no apparent reason in such a case why one should not insert a condition such as "no piece to weigh over 100 lbs." This would, of course, tend to disintegrate the whole system, as amongst the advantages to be gained are a more uniform practice in classifying scrap, which affords a better basis for negotiation, less expense in grading and sorting, more prompt delivery, less chance of error in despatch, and decreased overhead and handling charges. Thus, it appears to us that provision should have been made in the contract form for the mere insertion of the specification number and the quantity. Naturally enough, provision has been made for price, delivery and other normal business entries. Another rather remarkable omission is an arbitration clause so as to eliminate expensive litigation, but our knowledge of American business methods is insufficiently deep to press this criticism, as it may be taken care of in other directions. Amongst the seventy-five specifications there are many phrases which admit of latitude in interpretation, such as "free from excessive rust or corrosion"; "easily broken by an ordinary drop into cupola size"; "to be fully described at time of sale or purchase"; "must be clean material"; "badly rusted or corroded stock will not be accepted," and so forth. Thus a cheap method of arbitration does seem to us to be desirable.

Is such a system worth while introducing into this country? We personally have bought very large quantities of scrap, and the only time we have not received satisfaction is when we have used our own judgment and bought direct from the producer instead of through a merchant. In general the large scrap merchants are particularly reliable, and we have not heard of real demand for standardisation on lines similar to that effected by the Americans.

The International Foundry Congress at Düsseldorf

FINAL SESSIONS IN BERLIN

The International Foundry Congress in Düsseldorf was followed by a motor-coach trip through Germany of over two weeks' duration. This tour will not terminate until Wednesday, October 7, and it was possible for only a comparatively small number of the 2,200 members of the Congress to participate in it. The tour was arranged so that members spent September 24-26 in Berlin, and during that period the final sessions of the Congress took place. On these days the tourists were joined by a number of other members of the Congress who had either remained in Düsseldorf or had been otherwise engaged in the meantime.

On Thursday evening, September 24, the State Commissioner of Berlin, Dr. Lippert, received the party at the City Hall, and afterwards entertained them to dinner. Mr. W. Bannenberg (President of the Foundry Technical Association), in a short speech, expressed the thanks of the party to Dr. Lippert and to the City of Berlin.

On Friday, September 25, an impressively simple ceremony took place at the Tomb of the Unknown Warrior in Unter-den-Linden. Members of the International Committee of Foundry Technical Associations, headed by the President of the Committee, Mr. J. Léonard, proceeded to the tomb, and after a short address, Mr. Léonard, on behalf of the Committee, deposited a wreath.

Closing Session

The final session of the Congress was held in the Banquet Hall of the Zoological Gardens on Friday evening, Mr. W. Bannenberg presiding. A lecture by Dr.-Ing. Arnoldt on "Men and Machinery in German Foundries" followed, after which Mr. Léonard, on behalf of the International Committee of Foundry Technical Associations, expressed the thanks of the visitors to their German hosts for the hospitality which had been accorded them, and for the enormous amount of work they had done in preparing so large a Congress.

Greetings were then conveyed to the German hosts from representatives of several of the countries present, the speakers including Mr. T. Makemson, who spoke on behalf of Mr. Harry Winterton (President of the Institute of British Foundrymen), and Mr. V. Delport (President-Elect of the International Committee), who spoke on behalf of the American Foundrymen's Association.

The meeting was followed by a banquet, at which Mr. Léonard was the principal speaker on behalf of the guests, and Dr. Geilenkirchen (Director of the German Foundry Technical Association) responded.

A Discussion on Steel Castings

A joint meeting of the Iron and Steel Institute and the Institute of British Foundrymen is to be held at the Institution of Civil Engineers, Gt. George Street, Westminster, London, S.W.1, on Friday afternoon, October 30, at 2.30 p.m. The subject of discussion will be "The Second Report of the Steel Castings Research Committee" of the Iron and Steel Institute and the British Iron and Steel Federation (Special Report No. 15 of the I.S.I.). The contents of the Report are as follow:—(1) Introduction. (2) "Properties of Steel which affect the Quality of Steel Castings," by R. H. Greaves; (4) "Investigation into the Castability of Different Kinds of Steel," by J. H. Andrew; (4) "The Strength and Ductility of Cast Steel during Cooling from the Liquid State in Sand Moulds," by H. F. Hall; (5) "Note on the Work and Programme of Moulding Materials Sub-Committee," by S. H. Rees; (6) "The Present Position of Radiological Examination of Steel Castings," by V. E. Pullin, and (7) Appendix 1—Bibliography on the Fluidity and Viscosity of Metals, and Appendix 2—Liquid Steel Temperature Determination.

The chairman of the meeting will be Mr. H. Winterton, President of the Institute of British Foundrymen.

The sections selected for discussion will be presented by their authors and discussed individually. The programme of the meeting is as follows:—

(1) Opening of the meeting by the Chairman.

(2) Presentation of the Second Report of the Steel Castings Research Committee, by the Chairman of the Committee, Mr. W. J. Dawson.

(3) Presentation of Section II of the Report by Dr. R. H. Greaves, followed by discussion.

(4) Presentation of Section III of the Report by Prof. J. H. Andrew, followed by discussion.

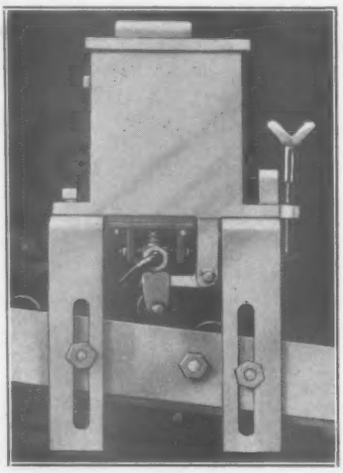
(5) Presentation of Section IV of the Report by Mr. H. F. Hall, followed by discussion.

The first report of the Steel Castings Research Committee was of great interest to all steel foundrymen and to foundrymen in other branches of the trade also; the second report is a very important publication and all members who can possibly be present are urged to do so.

The Iron and Steel Institute have placed a number of copies of the Report at the disposal of the Institute of British Foundrymen. Copies may be obtained on application to Mr. T. Makemson, Secretary, St. John Street Chambers, Deansgate, Manchester.

A Conveyor Chain Lubricator

The efficient lubrication of conveyor chains has been a problem, the solution of which has engaged the attention of engineers for many years past. The haphazard application of oil in copious quantities defeats its own object. Where applied by oil-can, brushes or swabs, the oil inevitably covers the whole chain, instead of reaching just those points which call for lubrication. C. C. Wakefield & Company, Limited, Wakefield House, Cheapside, London, E.C.2, have designed an entirely new conveyor chain lubricator, which is a compact, self-contained unit, with the additional advantages of being highly efficient, low in price and requiring nothing further than the provision of two brackets for mounting when being installed. The accompanying illustration shows the lubricator fitted to a conveyor. The rollers on the conveyor chain actuate the pump plunger projecting through the base of the lubricator, and oil is fed directly to the roller pins. The oil outlets are adjustable and are set in relation to the speed and the size of chain. The amount of oil delivered can be simply adjusted from zero to maximum and the lubricator can be rendered inoperative and free of the chain when not required. Lubrication starts and ceases with the movement of the chain itself. The lubricator is robustly constructed and is entirely British made.



Conveyor Chain Lubricator.

(*Concluded in next column.*)

Random Shots

Düsseldorf, the garden city on the Rhine, has been duly inspected and approved by a large number of British foundrymen and women. It is the cleanest city in Europe, has a nice selection of cabarets where one is charged reasonable prices, and is unutterably bored by the all too long diatribes of various species of Meister Komiker. The Kaskade is especially good and outshines the illuminated fountains of Blackpool or Southend, and the inter-table telephones are admirable for making discreet communications with your future girl friend.

* * *

On many occasions there were humorous interludes due to language difficulties. One prominent and wealthy member hired a taxi to take him to the Mussel House Restaurant, and on the arrival, the Jerry Jehu asked courteously, "Zu Essen?" meaning "You are going to dine here?" But the worthy member, knowing all about Krupps of Essen and its distance from the City of Düsseldorf, indicated that after all he only wanted a drive and would return and dine at his hotel.

* * *

One of "Marksman's" colleagues was visiting a famous champagne works near Düsseldorf, and after his umpteenth glass noticed the waiter was still busy refilling and tried to say "Nein" or "No" instead of which "neun" or "nine." This brought the apt remark from the waiter: "Drink that up, sir, and this will make ten."

* * *

Whilst the Department of Overseas Trade, in its reports on various countries, give a series of "hints to travellers," there is a further one we might add. Travellers to Germany, finding themselves interested in a Nazi procession, should remember to remove their pipes. We specially call attention to this, as one of "Marksman's" very best friends from the North got caught in a day dream. He was just dreaming how well a pint of mild and bitter would taste with a Frankforter sausage and sauerkraut, when he realised he had committed a "faux pas" through the hasty displacement of his pipe.

* * *

The British party undoubtedly found a friend indeed in Herr Hohner—a local political propaganda officer. He, with his very charming Bavarian wife, who well graced the costume of her native mountains, made the British party their special object for courteous attentions so indebted were the British contingent to this official that, under the benevolent leadership of Mr. and Mrs. Winterton, a souvenir in the shape of a coffee service was informally presented.

* * *

"Marksman," desirous of seeing both sides of the picture, decided to return to England *via* France, and halted at Metz. Here he picked up the following information worth noting:—(1) To procure a good skin on steel ingot moulds sandblast the beggars after each cast; (2) the French air force wear naval uniforms; and (3) if Mr. Cochrane ever brings the prize band of the crack Algerian regiment around the provincial music halls, do two things: (*a*) give your Scottish friends a treat, as the Highland pipers have nothing on the French colonial troops; and (*b*) take a large supply of cotton wool for plugging up ear apertures. So far as juggling with their bugles and drums-sticks, they are quite the equal of the drum major of the Guards.

"Marksman."

The Düsseldorf Foundry Congress

Below we publish a number of abstracts of the various Papers presented to the Düsseldorf International Foundry Congress. If readers will indicate that they would like us to publish any of them in full, we shall be only too pleased to do so should the demand be reasonably insistent. Abstracts of other Papers submitted will be published in future issues.

What May Foundry Practice Expect from Moulding Machines?

By Prof. Dipl.-Ing. U. Lohse.

The moulding machine is a machine tool, where the pattern plate represents the tool, whilst the moulding sand may be considered the material to be worked. In order to produce faultless moulds by means of the machine, a well prepared moulding sand is indispensable. In this study the ideal composition of sand for machine moulding is first discussed and ways are indicated as to how to approach this ideal. In practice it must be demanded that with trained workmen and in continuous operation a certain number of faultless moulds are produced per unit of time. The term "faultless mould" being clearly defined, it is then shown how such a mould may be obtained mechanically. First the mechanical removal of the pattern from the mould by the various methods, either by stripping up or down, by drawing or turning over are discussed—as well as their theoretical fundamentals and their applications for the different kinds of castings, special consideration being given to the possible sources of defects.

The conventional means of mechanical sand compression, such as ramming, jarring or sand slinging, are critically reviewed. The principles and the efficiency of the various ramming methods are interpreted. Selecting one or the other method depends upon the dimensions and the shape of the pattern to be moulded.

Thus, the theoretical basis of machine moulding being established, special consideration is given to the design and the operation of the moulding machines. Of prime importance are the surroundings where the machine has to work, as well as the operation by trained workmen, if both a long service-life and accurate performance are to be ensured. In view of the limitations imposed, only the power-driven moulding machines for producing the mould with a two-piece pattern are taken into consideration. Nevertheless, the statements made may also be valid for the other designs of mould and core moulding machines.

Basic Principles Underlying the Manufacture of Foundry Pig-Iron with Special Reference to Desulphurising

By Prof. Dr.-Ing. Paschke.

For the utilisation of lean acid ores the following procedure has been adopted in co-operation with E. Pleetz:—The ores are treated in the blast furnace, either in the condition as supplied or agglomerated, depending upon their physical qualities, limestone being added only in such amounts that, besides a fluid acid slag, a pig-iron high in sulphur is produced, which will be desulphurised after tapping by a basic slag or by other adequate means. By reducing the amount of limestone added, both the volume of the resulting slag and the coke consumption are decreased considerably. With blast-furnace slags containing 12 to 15 per cent. of alumina the minimum free-running temperature lies at 44 per cent. of SiO_2($CaO:SiO_2 = 1$). On the basic side the free-running temperatures ascend steeply, on the acid side, however, smoothly.

In the case of the usual coke blast-furnace slags the ratio $CaO:SiO_2$ is always higher than 1 owing to the sulphur; on the average it is 1:5, corresponding to a silica content of 34 per cent. The respective free-running temperature is higher by 200 deg. C. than with a silica content of 44 per cent. approximately. The hearth temperature may be maintained at a lower point in the acid process of the coke blast furnace than with the basic process. The higher the amount of silica and ferrous oxide in the slag, the lower will be the carbon and sulphur content of the pig-iron. The silicon content depends besides the silica available in the slag, upon the hearth temperature.

By means of this process, among other grades of pig-iron, foundry pig-iron may also be produced. It is recommended to desulphurise immediately after tapping by the use of soda ash. Before adopting the acid process, the most favourable conditions for the desulphurising action were determined by laboratory experiments. Special care has been taken to increase the efficiency of the soda ash. It is recommended to carry out the desulphurising action in a ladle, into which the necessary amount of fused soda ash has been placed before adding the pig-iron. In the case of very high sulphur contents the desulphurising is preferably carried out in two stages, using the slag from the finishing desulphurisation for the preliminary treatment. For the lining of the ladle densely burnt fireclay bricks with medium alumina content are especially suited. The treatment of the pig-iron with soda ash results, in addition to the desulphurising effect, in a remarkable improvement of quality. Synthetically produced high sulphur foundry pig-iron after desulphurisation exhibited a pearlitic structure with finely distributed graphite. It is also feasible to desulphurise the pig-iron with calcareous slags or with manganese. By means of the new process described other grades of pig-iron, *e.g.*, basic Bessemer pig-iron, may be produced besides foundry pig-iron. In addition, ores rich in titanic acid, alumina and sulphur may be utilised.

Cast Iron and Its Present Position as a Material of Construction

By Prof. Dr. A. Thum.

The great progress made in the modern machine construction and the increased capacity of engines, especially in the transport field, have led to requirements which the materials of the past could no longer meet. The occurrence of fractures minimised the safety of operation and inhibited further advance. Hence, materials with ever increasing strength values had to be developed.

The development of new steels and the increase of their tensile strength, however, did not substantially help to increase safety. The reason for this was that the increased ultimate strength of these materials could not be utilised to the best advantage with the present designs. It became evident that the tensile strength of a structural part is not only dependent on the material itself, but particularly on the design. The load carrying capacity is limited by the fact that notch effects cannot always be avoided. The conventional testing methods, *i.e.*, the so-called static methods, therefore, proved very unsatisfactory. Fatigue tests carried out have shown that the materials available have quite different fatigue properties depending on their application and that each design has its proper strength. This behaviour of the materials has led to the introduction of the definition "design strength" ("Gestaltfestigkeit"), *i.e.*, the strength depending on design.

New Testing Methods

From this point of view the necessity arises of testing the material in quite another manner than hitherto used. High tensile and elongation values, considered formerly as the exclusive and authoritative measure of quality, give an indication of the soundness of the material only. For the determination of the "design strength," however, the sensitivity to notch-effect of a material is of paramount importance, *i.e.*, the quality which defines to what extent the effect of a localised stress raiser, for instance grooves and notches, will be reflected in the behaviour of the material.

In order to utilise the high tensile strength of a material in the finished structures also, a favourable design must be selected with a view to obviating local discontinuities of the flow of forces and stress raising effects. In order to reach this aim in complicated cases, an easy deformability in the shaping of the material is a preliminary condition. The material must easily be deformed into every shape desired.

Therefore, for determining the usefulness of a material, not only its tensile strength is important, but also the easiness with which it may be given its shape. For judging a material accurately the test methods and conceptions hitherto prevailing have to be extended. Thus, a high elongation, for instance, which is considered to be a protection against failure by the engineer still adhering to the conventional theory of strength of former times, cannot fully be utilised in structures, where the effect of grooves or notches is encountered. Even with materials of highest elongation the values obtained from the finished structure are only a portion of the values as measured on the plain test bar. Particularly in cases of fatigue failures, the most frequently occurring trouble, the fracture occurs without any previous deformation.

The Field for Cast Iron

On account of the above facts the cast iron with its low elongation values as compared with steel has many advantages. It has been shown that cast iron, which may be considered an inherently notched material, is much less sensitive to external notches than steel. This lower notch-sensitivity of the cast iron is an immense advantage for structural parts under repeated stresses. Thus the endurance limit of a cast iron crankshaft with a tensile strength of 22 tons per sq. in. varies between 3.5 and 4.1 tons per sq. in., whereas a steel crankshaft has an endurance limit between 4.8 and 5.7 tons per sq. in. irrespective of its tensile strength being 44 or 95 tons per sq. in. These favourable properties of cast iron are further supplemented by its ease of supply as a cast material and a further advantage over most of the other cast materials lies in its high tensile strength and its relatively slight tendency towards piping and shrinkage, owing to the presence of graphite particles, acting against the shrinkage during solidification.

Selling by Quality, not Weight

Designers must endeavour to make full use not only of the tensile properties, but also of the ease of forming components in cast iron. By doing this, the principles of the lightweight construction are applied, as are sought in aircraft and automobile construction. It is evident that endeavours towards reduction of weight and increase of loading capacity should, of course, be made also in the field of general engineering. Besides these requirements, frequently highest rigidity is demanded, as for instance in machine tool construction. In this respect the monocoque method of construction, as it is applied in the aircraft industry, may exert its influence. Owing to its ease of manufacture and workability, cast iron lends itself excellently to hollow castings. With a thin wall thickness high durability and rigidity are obtained, especially by the application of closed sections. Thus the modern high quality cast iron requires new suitable designs in order to exhibit fully its outstanding features. The further development of cast iron alone cannot result in success, unless also the possibilities of advances in design are further extended.

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Therefore, the principle usually adopted by foundries to cast pieces as heavy as possible should be abandoned, and as a basis for costing a single casting, produced to the utmost perfection, should be adopted. Thus, both the designing engineer and the foundryman are confronted with difficult tasks.

Character of Surface and Surface-qualities of Cast Iron

By Prof. E. Diepschlag.

The examination of the external layers of a grey iron casting and the research concerning the constitution and the behaviour of the surface will be of importance for several reasons:—

The accuracy, smoothness and cleanliness of the surface of grey iron castings must continuously improve, especially as good surface behaviour will be of considerable commercial importance. Unclean and rough surfaces are the cause of increased cleaning costs. A good skin is the best protector against chemical reactions of many different kinds. Smooth, plain and faultless surfaces are in close relation to certain strength properties of the iron body. In all cases where surface coats are protected, such as enamels or metallic coats, the properties of the skin are of a decisive importance.

The examination of the surface behaviour of grey iron may be divided into parts, the constitution of the exterior metallic layers and the nature of the skin of grey casting. Microscopical testing of the surface of a slide inclined across the skin has been made with the result that the border of the metallic body is of a manifold crooked character with fine cracks here and there.

On the surface plane of the metallic body there may be seen a very thin layer of a dull blue-grey nearly black colour consisting of a fine surface separation of iron oxides, comprising the two chemical compounds of FeO and Fe_3O_4 and their solutions. Some points of the surface consist of small bright areas of partly sintered products. Further, there are splintery crystals of quartz embedded in the oxide layer.

High Oxygen Content

The origin of this surface constitution may be explained by a note of the conditions of melting and pouring the hot metal. Air being always in contact with the surface of the molten grey iron, silicon and carbon are oxidised gradually and at last there may be a more or less high content of oxygen in a thin exterior layer of the iron surface. During cooling and solidification of the melt FeO must be discharged out of a saturated solution. During further cooling FeO is partly converted into Fe_3O_4. These products react here and there with particles in the wall of the mould; the slower the speed of cooling and the finer the dust particles in the moulding sand the more the products react.

In addition there is some definite relation between the oxygen content of the iron and its property of wetting the mould. The property of throwing a more or less developed skin on the surface of a casting depends on a number of conditions such as the method of melting and pouring, composition of the iron alloy and quality of the moulding sand.

The external metallic layers of a casting are generally of a lower content in silicon and carbon, caused by the refining power of the air during pouring; on the other hand, the sulphur content is higher than in the inner parts of the casting. Therefore the hardness and brittleness of these outer layers are more or less higher than those of the interior.

During pouring the molten iron is pressed very closely against the roughnesses of the wall of the mould, provided that the pouring temperature is not too low. The smoothness of the iron surface is in a definite relation to the proportion of fine grain sizes in the moulding sand. Tests showed that there is a marked relation between the roughness of the test bar and the transverse test.

To prevent the moulding sand from burning into the surface of a casting a number of precautions may be at hand. Besides avoiding the admittance of an excess of air during melting and pouring, the generation of a neutral or reducing atmosphere in the mould, the use of a suitable lampblack, absence of fine dusty sand particles in the moulding sand and the production of a smooth surface of the mould by accurate working are of considerable importance.

Mechanical Properties of Cast Iron in Relation to Wall Thickness and its Position in the Carbon-Iron Diagram

By Prof. Dr.-Ing. Uhlitzsch.

A comprehensive review of the work carried out on these lines has been given by Heller, this work having been continued recently by Heller and Jungbluth. As a result of their investigations, the last mentioned authors have developed a diagram, from which direct readings as to the values for the relationship between wall thickness and ultimate strength can be taken.

The present study has been made with the aim of determining law-obeying correlations also between the wall thickness and the other tensile properties. As a basis to start with, the cast iron diagram, as given by Maurer, with its supplements, has been adopted. The purpose, therefore, was to determine correlations between four variables: carbon, silicon, wall thickness and one of the respective tensile properties. In order to obtain clear diagrams, at the outset two of these variables had to be substituted by one value. For this purpose curves of the equal ultimate strength, the equal transverse strength, the equal bend values and the equal hardness were plotted into the cast iron diagram, in accordance with the results of a study by Weichelt. From this diagram readings may readily be obtained as to the percentage of carbon to be selected with a silicon content of 2 per cent. in order to obtain the same tensile properties as possessed by a sample of any given carbon and silicon content. By doing so, a reference value for two variables is determined. It has been termed

$$K_{\sigma_B}, K_{\sigma'_B}, K_{Zf} \text{ and } K_{H_B}.$$

In the course of the work it has been made possible, by utilising the experimental results by Rudeloff, Maurer and Holtzhausen, Kleiber, Koch and Piwowarsky, and Weichelt, to check, on the one hand, the dependency of the tensile properties mentioned on the respective values of K, and on the other hand to prepare in addition sections through a ternary diagram, where the wall thickness has been plotted as a third variable.

For the direct practical use these diagrams, however, are of no service, since the data contained in the curves are valid only for the experimental conditions (process of melting, cooling rate, mould) chosen by the respective investigator. The trend of the curves, however, remains the same for all conditions, so that the data, modified according to the experiences of the foundries, may be embodied in the curves.

With a view to eliminating the influence of the experimental conditions, Heller has already proposed to determine not the absolute drop of the tensile strength, but the percentage reduction of the initial strength. The ultimate strength of the conventional test bar section can be assumed to be 100. Unfortunately, the results gained so far are not sufficient to establish such diagrams for all tensile properties dealt with here. It has been possible, however, to develop a diagram for the percentage reduction of the ultimate strength as a function of the wall thickness and K_{σ_B}, which diagram has already proved its usefulness in practice.

In addition, a diagram could be established, showing that the percentage reduction of hardness is a function of the percentage reduction of the ultimate strength. The ultimate strength of any given section may, therefore, be gathered from the difference of hardness between casting and test bar, provided the ultimate strength of the test bar is known. There is, however, not a sufficient number of empirical data available from practice, for checking the correctness of the diagram.

Influence of Tensile and Compression Stresses on Graphite and Phosphide Eutectic

By Dr.-Ing. F. Bischof.

For the tensile properties of cast iron the structure is an essential. Since stresses may set up in a casting, an accurate knowledge of the effect of these stresses on the structure is considered necessary. Up to now, no observations have been reported on the real influence of stresses on the formation of graphite and on the type of structure formed.

For producing tension and compression stresses in test bars a simple device has been used, the strain grid, by means of which two bars of 20 mm. diameter and 150 mm. length are pressed and pulled respectively into a flask. A third bar, cast simultaneously, was kept free from internal stresses. Preliminary tests indicated that the amount of graphite formed will not be changed by tension or compression stresses and that with a phosphorus content of about 0.3 per cent. the graphite formed in the compression bar is finer, whereas it is coarser in the tension bar. With higher phosphorus contents of about 1 per cent., the reverse is true, *i.e.*, the graphite will be finer in the tension bar and coarser in the compression bar. Heats with phosphorus contents of 0.26 to 1.73 per cent. confirmed the results of the preliminary experiments. The condition of the graphite in tension and compression bars varies with increasing phosphorus content. If with a phosphorus content of 0.26 per cent. the graphite formed is fine in the case of the compression bar and coarse in case of the tension bar, with phosphorus contents of 0.88 per cent. and above, the reverse will hold true. The condition of the graphite in the bar kept free from stresses is intermediate between that of the tension and compression bar. With medium phosphorus content of 0.57 per cent. the condition of the graphite is almost the same with all kinds of test bars.

Generally speaking, with the prevailing cooling rates the phosphide eutectic and the network respectively are finest in the compression bars and coarsest in the tension bars.

Recent Development of Manufacture of Heat-Resisting Cast Iron in France

By A. Le Thomas.

(*French Exchange Paper.*)

In heating cast iron to temperatures between 600 and 1,000 deg. C. the castings undergo changes, acting partly in the same, partly in opposite directions. These changes may be brought about by very different causes, as, for instance, by corrosion, by graphitisation, by cracks, fissures or blow-holes, which are associated with the formation of the phosphide eutectic. The numerous constituents of the cast iron structure, *e.g.*, pearlite, graphite, cementite, ferrite, the phosphide eutectic and so on, behave in a quite different manner, when exposed to the attack of oxygen, carbon monoxide, carbon dioxide, water vapour, nitrogen and sulphates. The oxides formed expand and swell, resulting in an increase of volume and the casting grows. In some cases the growth proceeds to a certain extent, stresses set up, which result in fissures and cracks. The growth of cast iron is

furthermore caused by graphitisation, which occurs throughout the whole section and which is a purely physical phenomenon. For a better understanding of these phenomena a mechanical device has been designed, in which, in front of a scale showing the carbon percentages for the total carbon content, a pointer can be moved, which separates from each other the proportions of combined carbon and graphite respectively. The pointer is attached to a ribbon slung around a pulley and carrying on one side a weight, whereas on the other end the ribbon is connected with a readily movable piston of an oil cylinder. For interpreting the graphitisation and its effects the dilatometer, as developed by Chevenard, was of great assistance, as could be shown clearly by a series of figures. The dilatometric analysis in addition shows to what degree the changes of volume are dependent on the heating and cooling of cast iron, and gives evidence of the important and very complicated course of graphitisation at the transformers A_c and A_r. The structural constituent phosphide eutectic, encountered in numerous castings rich in phosphorus, has a relatively low melting point, which is likely to occur at 950 deg. C. This, too, is the reason why frequently with dilatometric measurements up to 1,000 deg. C. a sudden decrease of volume is observed.

For minimising corrosion and all other causes of growth, relatively high amounts of silicon, aluminium or chromium are added to the cast iron, these elements forming either an adherent surface layer or producing a perfectly dense and rather unattacked structure. In addition, cast iron may be given a high resistance to corrosion at elevated temperatures by hardening it, thus producing a considerable amount of cementite, a structural constituent which is highly appreciated in this kind of casting, or an austenitic cast iron is resorted to, such as Ni-Resist, which contains as alloying elements nickel, manganese, copper and chromium.

The Physical Properties of High-Chromium Cast Alloy-Steel

By Dr.-Ing. K. Roesch.

The most commonly used chromium cast alloys have the following composition: (1) Chromium 25 to 32 and carbon 0.30 to 1.50 per cent.; (2) chromium 14 to 16 and carbon 0.10 to 0.30 per cent.

The structure of the material with 25 to 32 per cent. chromium consists of chromium ferrite and chromium carbide of the formula $(CrFe)_4C$. From the ternary system Fe-C-Cr, as established by Tofaute, Küttner and Büttinghaus, as well as from the investigations of E. C. Bain, may be inferred that the 30 per cent. chromium cast alloy does not undergo a structural transformation by annealing and that, therefore, the properties cannot be influenced in this way. The alloy with 14 to 16 per cent. chromium responds to heat-treatment, since with this analysis the γ-phase is reached at above 850 deg. C. approximately.

A most important feature of the chromium cast steel is its acid resistance, resulting from its tendency towards passivity. Experiments have shown that none of the existing theories alone can give an explanation for the phenomena of passivity in all cases. It is true that for the different cases one or other theory may serve as basis for an explanation. By applying the oxidation theory, especially developed by U. R. Evans, the passivity of the chromium cast alloy may be explained in the case of all oxidising acids. With the protective film theory of W. J. Müller, assuming a protective film of salts, the passivity of the chromium cast alloy in non-oxidising solutions can be explained. With the surface tension theory of G. C. Schmidt the phenomenon may be explained that chromium alloys, which are at the limit of corrosion resistance, may be made stainless by polishing the surface.

Potential measurements on a 30 per cent. chromium cast alloy indicated, that by immersion in nitric acid an active sample may be brought into the state of highest passivity in the course of several minutes. By treating a passive sample in sulphuric acid the passivity can be retained for several hours, returning afterwards into the active state intermittently. By applying a low counter-voltage, the passive condition may be retained also in sulphuric acid.

Corrosion Resistance Limits

The chromium and the carbon content account for the acid resistance of the chromium cast alloy. On the basis of numerous experimental heats the limit of corrosion resistance has been determined.

There are three groups, namely:—

The first group comprises the ferrite-carbide-chromium alloys, which are of the completely stainless type without heat-treatment.

The second group comprises alloys, which are rendered corrosion resistant either by heat-treatment or by polishing the surface.

The third group includes chromium alloys, which corrode heavily, but, owing to their good wear resistance, may be used for the manufacture of tools.

An additional advantage of great importance is the resistance to scaling of this material.

The tensile properties have been determined both by tensile tests at elevated temperatures and by creep tests. With reference to the creep test it is noticeable, that the chromium alloy, which is rather brittle at low temperatures, exhibits a considerable ductility at temperatures above 500 deg. C. By the addition of nickel the creep strength of the chromium alloy may be substantially increased.

The erosion resisting properties of all chromium cast alloys are not good. The ferritic alloy especially tends readily to seizing, since the hard carbide particles often crumble out from the soft matrix.

The wear resistance of the chromium cast alloys towards rapidly flowing liquids is very good owing both to their structure and their corrosion resistance.

The "life" has been tested by the method advocated by W. Ruff. In this respect the 30 per cent. chromium alloy particularly with carbon contents of 1 per cent. behaves approximately similar to malleable cast iron. The 15 per cent. chromium alloy, which is produced with low carbon contents with a view to good corrosion resistance and sensitiveness to heat-treating behaves similarly to plain cast steel as regards "life."

For the melting of the high chromium alloys the acid furnace and particularly the acid high-frequency furnace is to be preferred. Fundamental researches on the slag reactions in melting chromium cast steel in the acid furnace have been made by Körber and Oelsen.

Development and Present Position of Non-Ferrous Metal Alloys in Germany since 1933

By W. Claus.

By the government scheme for the provision of work and the elimination of restrictions to German armament, provision and economical use of raw materials have become a matter of vital importance. Obviously, both factors were stimulating to the non-ferrous alloy industry, which received a powerful impulse therefrom. The development thus stimulated differs substantially, however, from that of former times. The causes of the advancements are:—(*a*) Requirements based on technical and constructional considerations; and (*b*) requirements based on economy and efficiency considerations, but the most essential cause of this development originated from the requirements based on the establishment of a national economy of raw materials, that is, from commercial and economical necessities.

A general and permanent trend of development was thus accompanied by an advancement, which may be characterised by the adoption of the so-called "replace" materials.

These replace materials have been made available from a plentiful source, comprising long existing, but not as yet utilised, categories of material, and furthermore by the development of materials hitherto unknown.

A general outline is given of this advancement, special stress being laid on the requirements mentioned above. In the first place, the light alloys, *i.e.*, the alloys of aluminium and magnesium, in the second place, the alloys of copper, nickel, tin, lead, zinc are discussed.

Finally, the present state of this development for the whole trade is summarised, and the lines for the probable further advances are traced. Here the most outstanding waste and secondary metal problem is critically dealt with, an outlook being given as to future lines of solving this problem.

Properties, Use and Manufacture of Lead Bronze

By F. Höhne.

The production of lead bronze is stimulated partly by the low price of the lead and partly by the particular technological properties of this material. The reason why alloys of this kind have hitherto found only a rather limited use, particularly in Germany, is that fundamental researches were lacking, and difficulties regarding the alloying and melting technique had to be overcome.

The scope of this Paper is to give a survey on the theoretical principles and to report on the practical results in the alloy group "lead bronzes." The greatest difficulty in the melting of these alloys is to overcome the miscibility gap occurring in the lead-copper-base alloys. This may be achieved in two ways:—

Primarily by a special melting method, which consists in first heating the lead-copper alloy as high as possible and then holding it before pouring. By this way an emulsion is formed and the lead with its higher specific weight partly loses its tendency to segregation.

Secondly by the addition of an alloying element, which closes or narrows the miscibility gap. The combination of the two methods is of advantage and will therefore frequently be used.

The lead bronzes are preferably cast in green-sand moulds employing as many chills as possible. The fields of application of the lead bronzes are:—(1) Bearing materials; (2) pressure resisting materials, and (3) materials which have to be resistant to the attack of sulphuric acid and of water containing sulphurous acid.

As regards the properties of lead-copper-tin alloys which, in spite of the development of a new lead-copper-manganese-nickel alloy of high value, are among the most frequently used alloys of this class, the following statements are made:—

The tensile strength will be decreased by increasing the lead content and increased by increasing the tin content. With lead contents of about 25 per cent. the alloys, however, still show properties which do not exclude their use in any way. This applies also to the limit of proportionality and to the elongation, the values of which, with the analysis mentioned, are still sufficient for the use of these alloys as bearing materials.

In the wear tests with normal temperature and good lubrication and increasing lead content, the alloys showed an increase of the wear during the running-in period which, however, comes to a standstill afterwards. With insufficient or with no lubrication at all as well as with elevated temperatures, the lead bronzes are surpassing the pure copper-tin bronzes considerably as regards the bearing and running properties.

In cases where good resistance to wear is the main requirement, but minor stress is laid on the

mechanical resistance, bronzes with high percentages of lead (up to 25 per cent. lead) and with a low tin content (below 5 per cent.) are used.

If, however, a good wear resistance as well as mechanical resistance are required, the bronzes having 12 to 15 per cent. lead and 8 to 10 per cent. tin are used. In cases where bearing materials have to work at high temperatures with poor lubrication or only partial lubrication, lead bronzes are applied having 12 to 15 per cent. lead and 7 to 10 per cent. tin.

The Kinetics of Oxidation in Molten Zinc, Lead, Silver and Copper

By Prof. Dr.-Ing. A. Krupkowski and Ing. S. Balicki.

The report deals with the following problems: The manner of investigating the kinetics of the oxidation of liquid metals with constant temperature and in air; the selection of crucibles and the experimental difficulties and the use of a hydrogen atmosphere during the melting period.

Two categories of metals, distinguished by the solubility of their respective oxides, and difference of the oxidation process with both categories.

The oxidation of zinc and lead. The formation of a protective layer of oxides, which inhibits the oxygen diffusion. The oxidation proceeds according to the following equations:—

$$w^2 = k \cdot t$$

$$w = c\sqrt{t} \cdot e^{-\frac{A}{2RT}}$$

where: w = the amount of oxygen absorbed by 1 square centimetre of surface,
t = time,
A = energy of activation,
c = a constant.

For zinc: c = 0.34 grammes per cm.² min.½
A = 35,100 cal./mol. for a temperature range between 600 and 700 deg. C.

for lead: c = 3.39 grammes per cm.² min.½
A = 31,800 cal./mol. for a temperature range between 470 and 625 deg. C.

The oxidation of silver and copper. Absence of a protective film and the solubility of the oxides in the metal. The equation representing the kinetics of the oxidation of these metals:

$$w = k \cdot t.$$

The coefficient k as a function of the temperature and of the resistances. The process of oxidation is influenced by:—(1) The resistance at the contact area of the liquid and gaseous phases; and (2) the diffusion resistance of the nitrogen layer on the metal surface.

The substantial difference between the oxidation rate of copper in pure oxygen and air respectively. The phenomenon of vaporisation of metals and the limitation in applying these metals.

Recent Developments in the Manufacture of Light Alloy Castings

By Dr.-Ing. W. Linicus.

The irresistible advance of the principles of light-weight constructions, utilised first in aircraft construction, as well as the new conception of the economic use of raw materials has opened new fields of application to the technique of light alloy casting in Germany, not only as regards the tonnages supplied, but has also given a strong impetus to the constantly growing improvement of quality. The technical progress extends as much to the development of new high-grade alloys as to the improvement of the melting and casting methods and the subsequent treatment of the finished castings.

The production schedules of the leading light alloy foundries comprise sometimes nearly 50 different grades of alloys, including special alloys for permanent mould and die-casting and different stages of age-hardening. The selection of the best material for a given use, therefore, is not always an easy matter. Since the development of the materials for casting purposes has reached finality as far as analysis is concerned, a standardisation of the new alloys has been carried out recently (DIN 1713).

The various standardised types of alloys cover ultimate strengths from 5.5 to 19 tons per sq. in. In addition to alloys with moderate or good chemical resistance, alloys are available, which are highly resistant to sea-water (GAl-Mg and GAl-Mg-Mn). For castings of intricate shapes the eutectic aluminium-silicon alloys (GAl-Cu, GAl-Cu-Ni and their modifications) are preferred on account of their excellent "life." For particular requirements as to high tensile strength at high temperatures copper alloys and nickel bearing copper alloys have proved their suitability.

As regards the melting practice of the aluminium cast alloys attention is directed to the endeavours made to improve the metals remelted from the returned scrap by careful cleansing and refining methods. For various alloy types special covering, cleansing and fluxing compounds as well as different sand compositions have been developed. For the accommodation to the peculiar features of molten aluminium a marked progress in the design of special melting furnaces has been made.

The refinements made in the moulding and casting practice of light alloys have given the possibility of changing from a plurality of single castings to always larger units. Since the aluminium alloys lend themselves well to the production of permanent mould and die-castings, new applications have been found for cases where a large number of pieces is required.

For very high-stressed structural parts thermally age-hardened light alloy castings are gaining in favour. The application of the age-hardening technique to castings has presented a difficult task, especially with larger castings, both to the light alloy foundryman and the furnace builder. To-day, however, all these problems may be considered as solved.

When the manufacturers of components recently changed over from brasses and bronzes to light alloy castings, the question of giving the finished casting a pleasant and resistant surface was of prime importance. By selecting the most suitable alloys and an adequate casting procedure and by use of the Eloxal method of surface protection this problem could be solved in a quite satisfactory manner.

The comments of the author accompanied by slides give a thorough survey of the manifold tasks and results of the light alloy foundryman. They will be supplemented in many details by three other Papers dealing with the practice of light alloy casting

Contribution to the Estimation of Bonding Agents in Moulding Sand

By E. Schneider and M. Paschke.

Classifying the foundry moulding materials according to their clay content in strong, medium and weak sands, may possibly lead to over- or under-rating. This fact is already accounted for by abandoning the term "clay" and substituting the term "bond," whereby only the proportion which is able to absorb water is responsible for the strengthening effect in compressing the sand; hence the colloidal proportion only and not the clay as a whole is the deciding factor. Therefore, the amount of the bond, determinable by the well-known flotation method, is no absolute measure of its quality, since in addition a series of other variables is also of a certain importance, as for instance distribution of the grain size, the grain surface and the grain shape of the mineral constituents.

In order to find a standard, all variables influencing the bonding power and consequently the strength, besides the clay bond, had to be related, so that only the inherent properties of the bond could exert their influence.

This was accomplished in a simple manner by isolating the bonding materials of three grades of sand containing 12, 17 and 22 per cent. of bonding matter respectively, principally by using the flotation method. These isolated portions were then converted into synthetic sands by adding in all cases the same grade of quartz sand as weakening material. The resulting sands, containing 7, 10, 13 and 16 per cent. (test sands) of bonding material, were compressed at varying degrees of moisture and afterwards tested for compression strength.

Simultaneously the three original grades of sand and a further synthetic sand (comparison sample), which received the same amount of bonding material as the original sands, were tested too. The resulting strength data were plotted as a function of the water content, and the original sands, the comparison and test sands were compared with each other.

For the evaluation of the data, several definitions have been taken as a basis, thus enabling a direct comparison to be made. The variation of the strength within a moisture interval represents the sensitiveness to water additions; the index of a bond is equal to the specific strength, determined by integrating the specific average curve of strength values within the limits of 7 to 16 per cent. bond content of the respective test sand; in the same manner the colloidal index is defined as specific colloidal strength in an interval of 3 to 6 per cent. content of colloidal matter. As colloidal matter those plastic materials are indicated, which, after removing the "plastic clay" by agitating in cold water, can be isolated from the sand by boiling and decanting.

Among the three bonds examined, that with the highest colloidal content was the least satisfactory in quality, whereas that with the lowest content in colloidal matter showed the best properties. Thus under the conditions chosen and within the limits set out neither the bond as a whole nor the colloidal part can be evaluated quantitatively and that both a structural variance of the clay and certain differences in the bonding properties of the colloidal substances must be taken into consideration.

Modern Statistical Foundry Management

By Dr. Herbert Antoine.

Simultaneously with the introduction of modern methods of control in industry, statistics have found new and quite peculiar fields of application. Owing to the easy and flexible application and the possibility of obtaining quick records—book-keeping, the results of which generally come much too late, and unlike cost-accounting, which is rather one-sided—statistics have become nowadays one of the most useful and modern instruments of the works-management in solving plant control problems.

In order to keep the statistical work within reasonable limits it is first of all necessary to establish a clearly outlined working scheme, which fixes time and extent for the compilation of data. An approved plan for a foundry with the list of the most important groups of data to be compiled is explained. The starting point for all statistical work is the statistical control of the staff, so indispensable for a correct judgment of the plant's operation. Under this control once a day the number of workmen present should be ascertained, because (1) such a control is necessary and (2) an absence of workmen owing to illness or leave may cause a retardation in the working scheme, which may lead to delays in the delivery of orders. Therefore, a continuous comparison of the number of workmen present and the number absent is truly advisable.

For the classification of workmen—according to their occupation and departments to which their wages have to be charged—into production workmen and labourers, men and women, a universal scheme for collecting the respective data is given, which permits an answer being given to all questions. Forms for entering these data and examples of their evaluation are given for the control of the number of employees and their salaries. The data connected with the statistical control of the staff—such as age of workmen, family, distance of shop from dwelling should easily be made available from a suitable file prepared for this special purpose.

For the continuous rating and influencing of the level of wages a current control of wage rates has to be provided. Instead of the normal average data it is specially recommended to resort to the use of frequency curves. Thus a clear picture of the distribution and of the actual classification of wage rates is obtained. A typical example illustrates how the actual wage rates may deviate from the average value. Special attention should be given to the wages of labourers, which as far as possible should be subdivided according to the different kinds of costs.

Control of Raw Material

Whereas generally in all industrial plants a certain amount of attention is devoted to the control of wages, the control of raw material is neglected in most cases. It is not sufficient to rely upon the purchasing department buying at the lowest price. If not for other reasons, only for having a survey on the payment obligations for goods ordered, statistical control of the flow of raw material is advisable. The data thus compiled should give a clear picture of the withdrawals of stock from stores and of the stocks on hand. The daily production should be ascertained by means of a foundry report. The yield ratio (finished product: raw material), the proportion of rejections, and waste are sufficiently important to warrant being ascertained daily in form of percentage figures. Also here a comparison of actual performance and required performance is advisable.

In order to keep the workman from making scrap it is recommended to check the statistics of rejections in order to allot the latter to the individual workshop, whereby a considerable reduction in the amount of rejections can be attained. For judging the rejections themselves an analysis of the reasons by means of frequency curves is very instructive. Equally important is the knowledge, how the weights of the single castings influence the returns of the foundry. It may occur, that, owing to ignorance of the actual distribution of the weights of the single casting in the respective department, wrong estimates are sometimes used for the calculation; therefore, a casting's weight analysis, according to the respective weight groups, serves to illustrate the true conditions.

For the stocking of raw material, a statistical control of the finished stock should be provided. This can be done by various methods. Difference curves and the combination of output and delivery figures are discussed. Turn-over and orders on hand—as a measure for occupation and for the full utilisation of works capacity—are of special importance. Attention should be paid to different points of view for classification—production groups, home and foreign markets, clients, etc.

Finally the statistical analysis of the figures of costs-accountancy and book-keeping is dealt with. The development of costs must be followed systematically, especially in case of series production or changing occupation. A characteristic example dealing with costs for quantity production is given.

Amongst the statistics of the accounting department the statistics of finance and the statistical analysis of the balance-sheet are especially important. As the best production results can be lost by a bad financial policy, the works manager must carefully survey the financial situation and the balance-sheet. How is a well planned finance plan to be established and which points of view are important for the statistical analysis of the balance-sheet? With the discussion of these questions the report closes. By accompanying each problem discussed by a corresponding graph, it is shown how the graph—the useful application of which is especially emphasised—should be used in a methodically correct way.

Features in the Use of Scrap in Aluminium Foundry Practice

By Dr. R. Irmann.

When scrap is utilised in aluminium foundry practice, be it of known or unknown composition, the final characteristics of the alloy obtained must be established. Quite often, there is no possibility of effecting chemical analysis in the foundry; the pouring test is, of course, a great aid in the qualitative determination of the composition. Quite often, however, the scrap contains so many constituents that this test does not allow drawing definite conclusions as to the type of alloy envisaged.

The study of foundry characteristics, such as "life," shrinkage or hot shortness, is not very simple and can practically only be considered in foundry practice when the problem is one of remelting scrap.

The study of machining qualities, by planing or milling, is easily carried out but depends in too great a measure upon the test conditions, since for turning, for example, the feed, depth of cut and number of turns must be maintained constant and above all, the sharpness of the tools must be identical.

In spite of the fact that the mechanical characteristics play no important *rôle*, since the parts cast from scrap alloys are not intended to be submitted to considerable stress, it is nevertheless very important that the simultaneous fusion of several different alloys shall not give, finally, a metal its mechanical characteristics, particularly whose plasticity, are so poor that the alloy in question cannot be used even for parts not to be submitted to stress.

Using as a basis the DIN specification No. 1713 for aluminium foundry and rolling alloys, an attempt was made to draw up, diagrammatically, tables of combinations of scrap alloys, permitting the differentiation, in the alloys finally obtained, between those which are mechanically utilisable and those which cannot be used. In this way, scrap was classified in the following manner:—

(1) That which can be mixed in all proportions.

(2) That which can be mixed only in certain proportions.

(3) That which cannot be mixed at all.

The alloys of the Al-Mg and Al-Mg-Mn groups should never, generally speaking, be mixed with copper-containing alloys, since the essential characteristic of the Al-Mg and Al-Mg-Mn alloys is good corrosion resistance. In mixing Al-Si with Al-Mg or Al-Mg-Mn alloys, great care must be taken not to obtain a final alloy too rich in Mg_2Si, since the alloy would be too fragile. This is also true as to mixing the Al-Mg-Si alloys and the Al-Si alloys. In the case of the German alloy (Al-Zn-Cu), also, it is not desirable to add a magnesium alloy.

On mixing together high copper-content alloys with high silicon content alloys, the alloys obtained are unusable because of their fragility. However, it should be noted that the combinations which seem unusable because of their fragility may be considered for certain special cases, such as for example in the casting of pistons.

From what has been said it may be seen that even the mixture of two different alloys, and although their compositions may be known, requires technical knowledge which foundry foremen usually do not possess.

By citing a few examples of scrap alloys, it was found easy to show which alloys could be utilised, from the viewpoint of their strength and plasticity, and which could not. For each of these alloys, sand cast tensile samples were made and the average values of tensile strength and elongation determined.

As it is generally impossible, in foundry practice, to resort to tensile tests, a test was sought to determine whether the elastic and plastic properties of the metal could be ascertained, using the transverse test on a 5 mm. sand-cast flat sample and determining the yield point by bending, the tensile strength by bending and the angle of bending on rupture.

In carrying out this test, a very simple lever arrangement and counterweight was devised which permitted carrying out the test by fixing the sample in a vice. The load adopted for the yield point by bending is that which, under the selected test conditions, gives a permanent angle of bending of 2 deg., the test then being continued until rupture.

The ratio between the yield point by transverse and the tensile strength by bending agrees very well with the ratio between yield point (0.2 per cent.) and tensile strength obtained in the static transverse test. One is therefore authorised, after testing alloys the mechanical characteristics of which are known by means of the transverse test, to utilise these results to calculate with sufficient accuracy, according to the results of the transverse test, the tensile characteristics of any alloy. Further, the measurement of the angle of bending at rupture gives an idea of the capacity for deformation of the alloy. It is therefore possible, thanks to the use of the transverse test, to classify among the standard known alloys an alloy cast from scraps, whose composition and mechanical properties are both unknown.

Publication Received

The Lochaber Water Power Scheme. Published by the British Aluminium Company, Limited, and the North British Aluminium Company, Limited, Adelaide House, King William Street, London, E.C.4.

For those interested in civil engineering, this book must indeed be of fascinating interest. For the reviewer, however, who probably represents the "man in the street" the main interest lies in the rather awe-inspiring illustrations, and the enormous amount of work such schemes give to the foundry industry. The book is beautifully presented and is of the type that compels the attention of the layman. The scheme is a far greater engineering achievement than the Mount Cenis, the St. Gothard or the Simplon tunnels, but because it is used for water instead of passenger trains, it has not appealed to the public imagination to the same degree; yet it is fifteen miles long! Those fortunate enough to receive a copy of this book can indeed count themselves fortunate.

Catalogue Received

Sand-Preparing Machines. A leaflet received from O. N. Beck, 11, Queen Victoria Street, London, E.C.4, describes the "Junior" sand-preparing machine. It is of the type which propels the sand fed into it at high speed through the rotary action of a studded drum. It is portable and made in two models, the smaller one using 2 and the larger one 3 h.p. for actuation. The larger model throws from between 1 to 9 yards and the claim is made that thorough mixing is effected. Usually in this type of machine, the action is so rapid that only aeration is effected.

Studies of Casting Stresses in Chilled Iron Rolls*

By J. ERLER, Ansonia

The successful application of any engineering cast iron is dependent upon its ultimate strength and the stresses which may be set up during the manufacturing process or during the use of the material. When using chilled iron castings three major stresses determine the limits of its usefulness:—(1) Stresses set up by the applied load; (2) stresses set up by temperature variance within various sections of the roll, and (3) stresses formed in the casting process. Therefore the load capacity of chilled iron is entirely

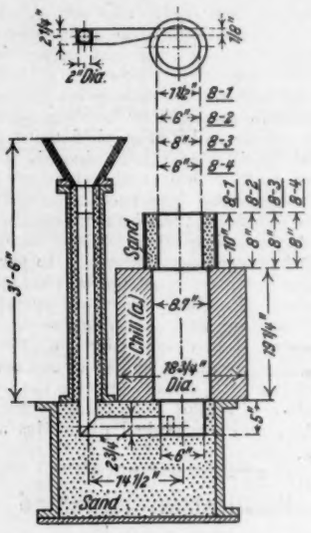
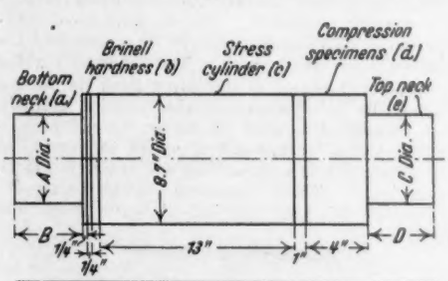


FIG. 1.—ARRANGEMENT OF THE MOULD.

dependent upon the amount of temperature and casting stresses combined.

By the rolling of metals, either hot or cold, considerable heat is created on, or transferred to, the surface of the roll. This heat will be transmitted from the surface to all sections of the casting, and the process will take place until a thermal equilibrium is created. Chilled iron rolls which are applied in the organic industry, such



Roll No.	8-1	8-2	8-3	8-4
A	6"	6"	6"	6"
B	5"	5"	5"	5"
C	7½"	6"	8"	6"
D	10"	8"	8"	8"

FIG. 2.—DIMENSIONS OF TEST CYLINDER.

as paper and rubber, are by far less subject to either very drastic or very wide temperature variations.

Casting stresses are created by the manufacturing process; by moulding methods; by treatment of the castings after pouring and by stripping from the mould which, combined with the metallurgy of chilled iron, are of a complex nature in chilled iron rolls. Casting stresses can be of such magnitude that by normal stresses the load capacity of a roll is insufficient and causes failure as soon as a fraction of the pre-determined load is applied; an experience only too well known to the roll maker as well as the roll user. Foundry stresses, unknown in their magnitude, will often lead to controversy between roll makers and users.

In order to visualise the stresses in their extent and direction it will be necessary to picture the solidification of a chilled iron roll. The roll founder must select his metal in such a way that the carbon in the chilled section should be in an entirely combined form, so producing a white structure with a pronounced ingotism; an iron which is strong, hard, but very brittle. A pearlitic grey iron structure is desired in the inner section of the roll which will be reasonably soft, weak and less brittle, having a great damping capacity.

Major Factors in Cooling Stresses

Two major factors will set up cooling stresses: the different temperatures within the various sections of the roll at the same time and the shrinkage characteristics of white and grey iron which vary entirely above the pearlitic point.[1]

During the pouring, the metal next to the chill will solidify instantaneously when coming in contact with the same, so that a shell will be formed with a thickness of approximately the desired depth of chill.

The roll loses its contact with the chill about eight minutes after pouring, after which time the rate of cooling will decrease considerably, due to the gas film between the chills and the roll and the low thermal conductivity of white metal. These phenomena produce the grey iron centre of the roll. The stress, during the period of solidification within the roll, will change continuously in its magnitude and direction. According to E. Schuz[2] the final casting stresses of chilled iron have the following stress:—

A compression zone from the outside of the roll will decrease toward the inside of the roll until reaching value zero, which will then change to a tension stress further to the centre until it reaches a value which is equal to the tensile strength of the material in the pipe or middle of the roll.

J. S. Caswell[3], in his investigation, discussed longitudinal, tangential and radial stresses. In his conclusion the tangential and longitudinal stresses show similarities; a tension stress on the outer zone decreasing to zero toward the axis of the roll and continuing from there as a compressive stress which, after reaching a maximum, decreases to zero with a tensional stress in the roll middle. The radial compressive stress increases from zero on the outer face to a maximum and declines to zero again with tension in the middle of the roll. His investigation emphasises the effect on the stress system of stripping the roll; the accelerated cooling will increase the shrinkage rate at every point, and it is fastest at the surface, but the shrinkage at any point is resisted by the slower cooling metal nearer the centre.

During the period of cooling of the roll even the chilled iron, with its high rigidity at elevated temperature, releases a great deal of stress, so that the final stress within the roll will be of a very complex nature and hard to visualise both in extent and direction.

The internal stresses exist in the form of a balanced system in any metallic structure. Both in the ferrous and non-ferrous metals a great deal of attention has been given to internal stresses either produced through form changes or cooling.[4] In order to study stresses it is most essential that the test pieces investigated should have a rather simple form. Fortunately, the cylindrical form of chilled iron rolls represents a body in which stresses can be easily measured.

For rods, bars and pipes, Heyn's[4] formula has been the basis for most investigators. This method depends on the removal of thin layers, resulting in a deformation of the remaining metal due to the unbalanced system of internal stresses. Heyn's formula enables one to calculate the internal stresses for each layer.

1. $$S_n = \frac{E}{L^1} \cdot \frac{d_n^2 (L_n - L_0) - d_{n-1}^2 (L_{n-1} - L_0)}{d_{n-1}^2 - d_n^2}$$

S = Stress in nth layer.
E = Modulus of elasticity.
L^1 = Length turned down.
d_n = Diameter of turned down part after nth cut.
d_{n-1} = Diameter of turned down part after $(n-1)$ cut.
L_0 = Initial length of bar.
L_n = Length of bar after nth cut.
L_{n-1} = Length of bar after $(n-1)^{th}$ cut.

Based on Heyn's work, Sachs[4] designed a method which will give the accurate determination of stresses in a triaxial system. His work in the investigation of stresses in drawn brass pipe is carried out in a cylindrical form. The

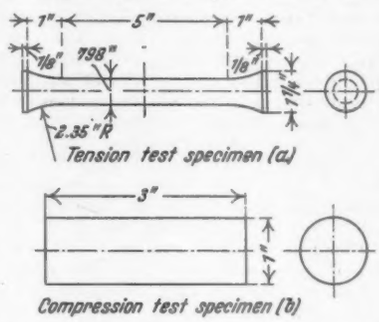


FIG. 3.—DIMENSIONS OF TENSION AND COMPRESSION TEST SPECIMENS.

change of length and diameter after the removal of each layer allows an accurate calculation of longitudial, tangential and radial stresses according to the following formula:—

2. *Longitudinal stress*

$$s = s' + s'' = \frac{E}{1-\gamma^2} \cdot (F_b - F) \frac{(d\alpha + \gamma d\beta)}{dF} - \frac{E}{1-\gamma^2} \cdot (\alpha + \gamma\beta)$$

3. *Tangential stress*

$$t - t' + t'' = \frac{E}{1-\gamma^2} \cdot (F_b - F) \frac{(d\beta + \gamma d\alpha)}{dF} - \frac{E}{1-\gamma^2} \cdot \frac{F_b + F}{2F} \cdot (\beta + \gamma\alpha)$$

4. *Radial stress*

$$r = r' = \frac{E}{1-\gamma^2} \cdot \frac{(F_b - F)}{2F} \cdot (\beta + \gamma\alpha)$$

s' t' r' = Released stress by removal of metal.
s'' t'' r'' = Remaining stress in test piece.
E = Modulus of elasticity.
γ = Poisson ratio.
F_b = Complete cross section of undrilled cylinder.
F = Removed cross section.
dF = Cross section of one removed layer.
α = Unit length change.
β = Unit diameter change.

Neither grey nor chilled iron has a true modulus of elasticity, but for the purpose of this investigation a workable modulus determined by stress-strain curves up to one-quarter of the ultimate strength can be applied.[5] Furthermore, in dealing with chilled iron, both the modulus of elasticity and the Poisson ratio represent varying values in each section of the roll. It is, therefore, necessary to determine these two factors over the entire cross section in order to find the modulus of elasticity and

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the Poisson ratio for each removed section and the remaining one. Therefore, the Sachs formula applied to chilled iron must be revised to take care of the change in modulus of elasticity and Poisson ratio:—

5. *Longitudinal stress*

$$s = s' + s'' = \frac{E_2}{1-\gamma_2^2}(F_b - F)\frac{(d\alpha + \gamma d\beta)}{dF} - \frac{E_1}{1-\gamma_1^2}\cdot(\alpha + \gamma\beta)$$

6. *Tangential stress*

$$t = t' + t'' = \frac{E_2}{1-\gamma_2^2}(F_b - F)\frac{(d\beta + \gamma d\alpha)}{dF} - \frac{E_1}{1-\gamma_1^2}\cdot\frac{F_b + F}{2F}\cdot(\beta + \gamma\alpha)$$

7. *Radial stress*

$$r = r' = \frac{E_1}{1-\gamma_1^2}\cdot\frac{F_b - F}{2F}\cdot(\beta + \gamma\alpha)$$

E_1 and γ_1 = Modulus of elasticity and Poisson ratio of removed section.

E_2 and γ_2 = Modulus of elasticity and Poisson ratio of remaining section.

Test Procedure

For the experimental work, chilled iron rolls with 8.7 in. diameter and 19 in. long in the "as cast" state were selected, because the procedure required machining in very close limits—± 0.002 in.—and, furthermore, the calibration of length and diameter to ± 0.0001 in. at various positions could be done more easily than with specimens of large dimensions.

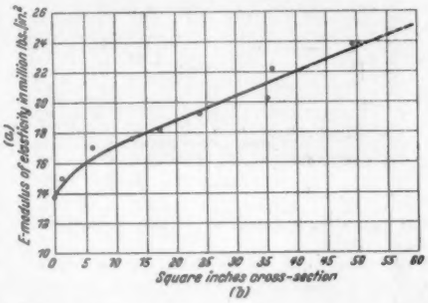


Fig. 4.—Relation between Modulus of Elasticity and Section.

The rolls were set up for pouring with the ordinary foundry practice for chilled iron rolls used in this country and according to dimensions as shown in Fig. 1.

For determining the stresses, four rolls were selected and numbered 8-1, 8-2, 8-3 and 8-4. The dimensions of the rolls themselves, as well as the runner and ingate, are the same, but the top neck of rolls Nos. 8-1 and 8-3 was varied from the accepted standard used on Nos. 8-2 and 8-4. The thought occurred that a quick setting of the top neck may influence stresses within the roll. All rolls have a clear chill of ½ in. with the exception of No. 8-4, which has a chill depth of ¾ in.

In the making of these rolls an attempt has been made to produce a minimum stress by selecting the proper melting, pouring and moulding practice. The metal was melted from a 100 per cent. chilled roll scrap mixture, hand picked, from rolls of the same diameter, depth of chill and composition. The melting unit was a basic electric furnace with a carbide slag.

All rolls were made from the same heat, and in order to increase the depth of chill in No. 8-4 pyrites was added to the metal in the ladle at 1,455 deg. C.

In Table I all data are given which have been recorded during the manufacture of the rolls. The rolls were left in the chills for 80 hrs. to allow very slow cooling, and when stripped from the chills measured approximately 51 deg. C.

The rolls were ground with an emery wheel according to the roll grinding practice about 0.05 in. on the side in order to allow the correct measuring of diameter and length of the test pieces. After the final grinding the rolls were cut in three sections (Fig. 2), one for stress determination by removal of layers; one for specimens of compression test bars, and one for hardness test and metallographic characteristics over the entire cross-section.

Due to the difficulty of turning chilled iron without heating the test piece, which might relieve stresses, as well as the desire to obtain the correct stresses on both the outside and the centre of the roll, the large logs were first bored out in the centre, 1 in. dia. removed per bore, and then ground on the outside to a ¼ in. less dia. per grind.

After boring out each layer the test logs were brought to a part of the room having small temperature change and left there for at least 10 hrs. before calibrating. The diameter was measured on both ends and on the middle of the test piece in four positions 45 deg. apart and the length on four positions 90 deg. apart. The results were corrected to a normal temperature of 22 deg. C.

When reaching the mottled section, after boring a 6 in. hole into the centre of the roll, the outside layer—⅛ in. thick—was removed with an emery wheel, water cooled during grinding. The length measurements were taken in the same way as on the boring procedure, but the diameter had to be calibrated on the inside

Table I.—*Manufacturing Data.*

	No. 8–1.	No. 8–2.	No. 8–3.	No. 8–4.
Furnace temperature, deg. C. ..	1,512	1,512	1,512	1,512
Pouring temperature, deg. C.	1,290	1,290	1,285	1,283
Temperature of chills before pouring, deg. C.	132	137	132	137
Pouring time, sec.	12	16	15	11
Roll stripped from chill after pouring, hrs. ..	80	80	80	80
Diameter in rough. in. ..	8.71	8.70	8.73	8.71
Length in rough, in.	19	19	19	19
Diameter of test piece after grinding, in. ..	8.6221	8.6164	8.6165	8.5798
Length of test piece after grinding, in. ..	12.9121	12.9503	12.9689	12.9727

Chemical analysis.

	No. 8–1.	No. 8–2.	No. 8–3.	No. 8–4.
T.C	3.54	3.51	3.50	3.50
Si	0.52	0.52	0.52	0.52
Mn	0.25	0.25	0.25	0.26
S	0.03	0.032	0.03	0.05
P	0.39	0.42	0.41	0.41
Clear chilled iron		½ in.		¾ in.
Mottled iron ..		⅛ in.		⅛ in.

of the bore and four readings were taken, 45 deg. apart. Diameter determinations in the middle of the roll could not be calibrated due to mechanical difficulty to insert a gauge exactly to that point. It was necessary to make a small finishing cut in the bore to locate and mark the points for calibration, which accounts for the boring increase to over 6.002 in.

The points for length measurement had to be re-located too in order to allow a machining of the shell to the minimum thickness by grinding. The average grinding and boring results are given in Table II.

The gauges used for the calibration of the specimens were correct to 0.0001 in. and checked before each reading with standard Invar bars. The boring and grinding were done with a maximum allowance of ± 0.002 in.

When the test pieces reached a dimension of approximately ¼ in. in thickness the machining had to be discontinued, due to difficulty of proper alignment and danger of cracking the shell during grinding caused by wheel pressure.

For the determination of the relative modulus of elasticity as well as the Poisson ratio of the entire cross section, tension and compression specimens (Fig. 3) were taken from a roll of the same dimension—8.7 in. dia. and 19 in. long. The depth of chill made it impossible to obtain a test bar entirely of a white structure. A small amount of grey iron was present in both the tension and compression bars when taken from the chilled section.

The relative modulus of a force which is ¼ or less of the ultimate strength shows an increase from the centre of the roll to the outside (Fig. 4). Even though the bars were not of the same dimensions, the modulus compression was equal to that by tension within the limits of the experimental error when the stress did not exceed ¼ of that of the ultimate tension.

Difficulty will arise when stresses exceed this limit and it will be necessary to select the proper relative modulus of elasticity from the stress-strain diagram. This will occur more often in

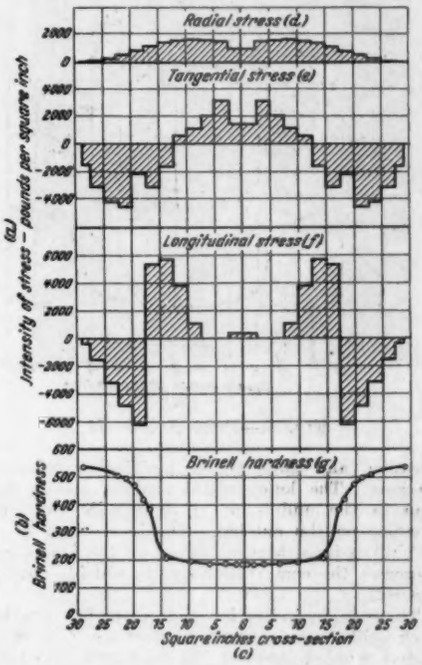

Radial stress (d.)
Tangential stress (e)
Longitudinal stress (f)
Brinell hardness (g)
Intensity of stress – pounds per square inch (a)
Brinell hardness (b)
Square inches cross-section (c)

Fig. 5.—Roll No. 8—1.

the grey iron section than in either the mottled or chilled iron area due to the high rigidity and ultimate strength of the latter.

Roll number 8—4 with the deepest chill had a smaller area of mottled iron than the other rolls due to the effect of the increased sulphur. It was, therefore, permissible to use the same relative modulus curve in all four cases. For check purposes compression test bars 4 in. long and one inch in diameter were taken from each 8.7 in. diameter roll. The results were compared with those in the above curve and checked within 5 per cent.

It was impossible to determine accurately the Poisson ratio and stresses up to 10,000 lbs. per sq. in. with the instruments available. Therefore, this factor was obtained from the formula[6]:—

8. $$E_c = \frac{E_t}{3(1-2\gamma)}.$$

9. $$\gamma = 0.500 - 0.167\frac{E_t}{E_c}.$$

E_t = Modulus of elasticity by tension.
E_c = Modulus of elasticity by compression.
γ = Poisson ratio.

According to the formula, the Poisson ratio for a stress of ¼ of the ultimate tensional strength is equal to that of steel, *i.e.*, ⅓. Varia-

tion of the factors will have a small effect on the results because the volume is in the form of a square or a product of small dimensions.

Discussion of Results

The results which are plotted against the cross-section of the roll in Figs. 5 to 8 show that those stresses below the zero line are negative or compressive, and those above, positive or tensional stresses. The longitudinal stresses are in tension in the middle of all four rolls and compressive on the outside. The increase of depth of chill reduces tension forces on the inside and increases the compression on the outside zone of the roll.

There is an indication that a smaller size top neck will have a similar effect on the stress system when comparing No. 8—2 and 8—3 rolls.

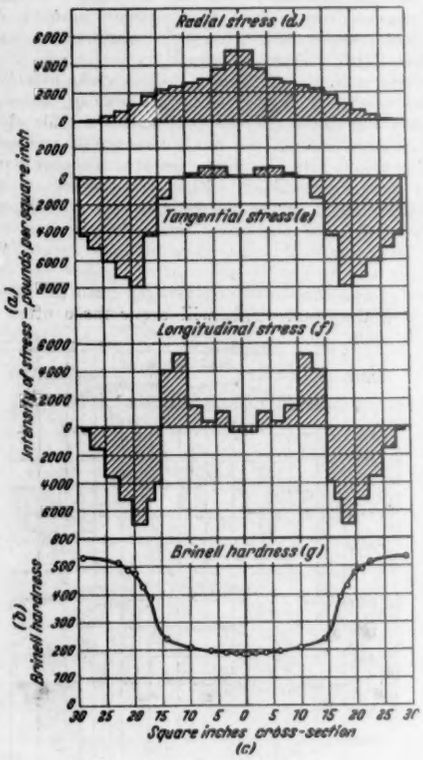


Fig. 6.—Roll No. 8—2.

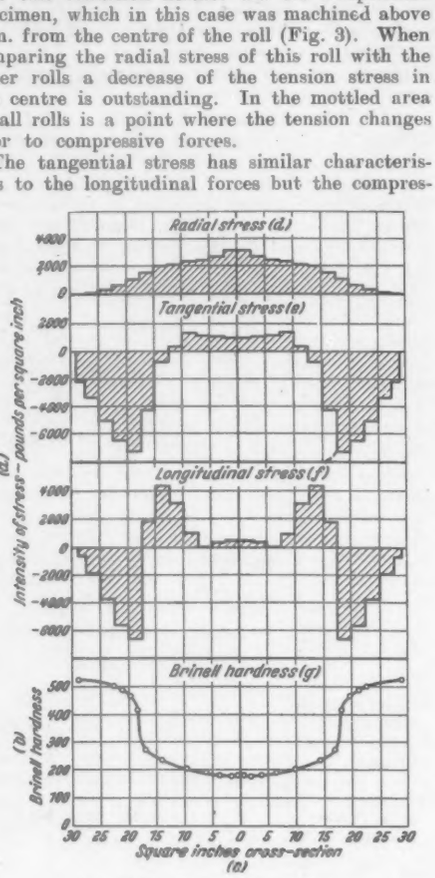


Fig. 7.—Roll No. 8—3.

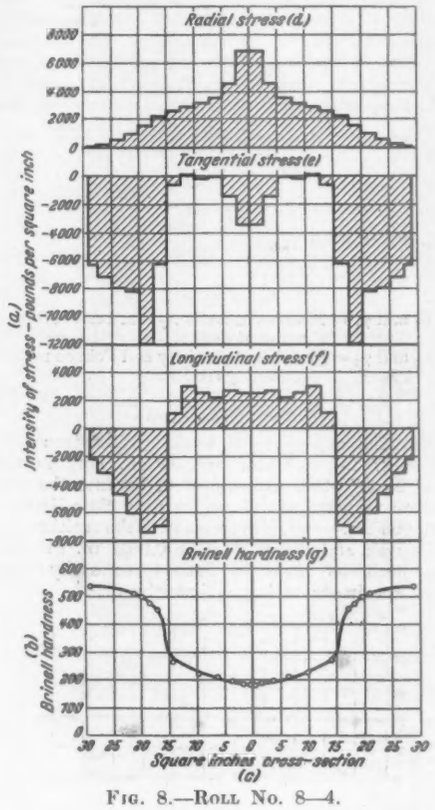


Fig. 8.—Roll No. 8—4.

The No. 8—1 roll, with the smallest top neck, could not be properly fed. In all probability the iron in the centre of the roll was open but not to the extent that it was noted by visual inspection or during machining. The location of the test piece for Brinell hardness determination and for metallographic inspection, taken from the bottom of the roll, did not indicate this condition neither did the compression specimen, which in this case was machined above $\frac{3}{8}$ in. from the centre of the roll (Fig. 3). When comparing the radial stress of this roll with the other rolls a decrease of the tension stress in the centre is outstanding. In the mottled area of all rolls is a point where the tension changes over to compressive forces.

The tangential stress has similar characteristics to the longitudinal forces but the compressive area extending to the change from mottled-grey iron and the tension in the middle area are by far less pronounced than is the case in the former stress. The tension force in roll No. 8—4 is practically zero and the compressive stress has a more pronounced maximum than any other roll. The centre of this roll is in compression whereas all other rolls at that area have tension.

The radial stress is tension in all rolls. The No. 8—1 roll has the smallest stress and the No. 8—4 roll has the largest, with a considerable increase in the centre.

The setting up of the metal in the top neck indicates an effect on the magnitude of the stress in rolls, more so in the centre than on the outside. Radial stress will be reduced when the solidification of metal in this part of the roll is retarded.

If the depth of chill is increased the entire mass of the roll of the same dimension will solidify quicker than a roll with a lighter chill, therefore, the maximum compressive stress on the outer zone and tension in the centre show a definite increase.

The procedure of making these rolls was selected to obtain minimum stress, nevertheless all rolls showed a considerable amount of stress. If the stress can not be reduced to a small percentage of the ultimate, it is desirable to have compression on the outor and tension on the inner zone of solid rolls.

Table II.—*Grinding and Boring Results.*

Dia. of bore in in.	No. 8–1.		No. 8–2.		No. 8–3.		No. 8–4.	
	Length In.	Dia. In.	Length In.	Dia. In.	Length In.	Dia. In.	Length In.	Dia. In.
0	12.9121	8.6221	12.9503	8.6164	12.9689	8.6165	12.9736	8.5798
1	12.9122	8.6221	12.9510	8.6169	12.9693	8.6168	12.9743	8.5803
2	12.9120	8.6221	12.9506	8.6168	12.9692	8.6167	12.9742	8.5803
3	12.9121	8.6223	12.9507	8.6169	12.9693	8.6168	12.9744	8.5804
4	12.9122	8.6225	12.9508	8.6171	12.9697	8.6172	12.9746	8.5806
5	12.9122	8.6224	12.9507	8.6173	12.9692	8.6173	12.9750	8.5809
6	12.9127	8.6231	12.9518	8.6179	12.9700	8.6178	12.9758	8.5815
Thickness of layer ground off.								
0	12.9121	6.0076	12.9508	6.0074	12.9692	6.0074	12.9752	6.0071
¼	12.9119	6.0076	12.9506	6.0075	12.9689	6.0075	12.9752	6.0071
½	12.9114	6.0077	12.9501	6.0073	12.9684	6.0073	12.9748	6.0070
¾	12.9105	6.0075	12.9491	6.0072	12.9675	6.0071	12.9743	6.0070
1	12.9105	6.0075	12.9494	6.0075	12.9674	6.0072	12.9743	6.0070
1¼	12.9103	8.0076	12.9491	6.0073	12.9674	6.0073	12.9741	6.0070
1½	12.9101	6.0076	12.9490	6.0074	12.9677	6.0073	12.9743	6.0072
1¾	12.9104	6.0076	12.9484	6.0072	12.9672	6.0072	12.9735	6.0070
1	12.9099	6.0075	12.9485	6.0073	12.9668	6.0071	12.9734	6.0071

Summary

1.—Sachs' method and modified formula may be used to study stresses of chilled iron rolls without any great difficulty if such stresses do not exceed ¼ of the ultimate.

2.—If the relative modulus of elasticity does not exceed ¼ of the ultimate, it will increase from the centre of the roll to nearly double on the chilled zone. Tension and compression have the same relative modulus within those limits.

3.—If the relative modulus of elasticity does not exceed ¼ of the ultimate strength the Poisson ratio—¼—can be calculated.

4.—The stresses are compressive in the surface and tensional within the roll when the rolls are stripped at a very low temperature.

5.—The rate of solidification of the metal in the necks has an effect on the magnitude of the stress within the roll.

6.—Deeper chill will increase the tangential stress on the outer zone and the radial stress in the centre of the roll.

Acknowledgment

The author wishes to express his appreciation to the officials of the Farrel-Birmingham Foundry & Machine Company for permission to publish the material contained in this Paper and is greatly indebted to the International Nickel Company for the use of the facilities in their research laboratory.

(*For bibliography see opposite page.*)

The Iron and Steel Institute

AUTUMN MEETING AT DÜSSELDORF

The Autumn Meeting of the Iron and Steel Institute was held in Düsseldorf last week at the invitation of the Verein deutscher Eisenhüttenleute, acting on behalf of the German iron and steel industry. The meeting commenced on Monday, September 21, and concluded last Saturday. Mr. James Henderson, J.P., was Acting President during the meeting owing to the absence of Sir H. C. H. Carpenter, F.R.S., through indisposition.

RECEPTION COMMITTEE

A large and influential Reception Committee was formed to make the necessary arrangements, under the guidance of Dr.-Ing. Fritz Springorum (President, Verein deutscher Eisenhüttenleute), the Hon. Secretary being Dr.-Ing. O. Petersen (Director of the Verein).

Mr. James Henderson, J.P.
(Acting President of the Iron and Steel Institute).

OPENING SESSION

The General Meeting of the Institute was held at the Tonhalle, Düsseldorf, on Monday, September 21, Dr.-Ing. Fritz Springorum (Chairman of the Reception Committee) presiding at the commencement of the meeting.

At the outset of the proceedings the members stood in silence for a few moments as a token of respect to the memory of Prof. Henry Le Chatelier, a Bessemer Medallist and an Hon. Vice-President of the Institute, who had died the previous day.

Address of Welcome

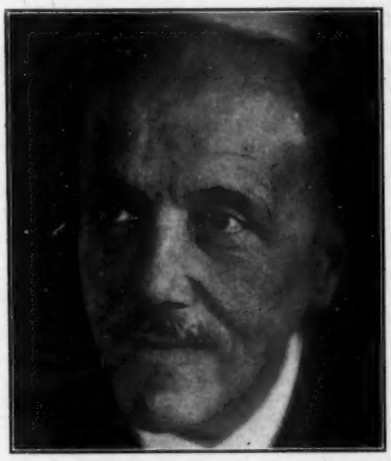
Dr. Springorum *(speaking in German)* extended a hearty welcome to the Institute on behalf of the Verein deutscher Eisenhüttenleute and on behalf of the Reception Committee. He expressed his sincere regret that it had been impossible for Sir Harold Carpenter, the President of the Institute, to preside over the meeting owing to illness, and wished Sir Harold a speedy and complete recovery. At the same time, he welcomed the fact that Mr. James Henderson, the Honorary Treasurer of the Institute and a metallurgist of world-wide reputation, had consented to take Sir Harold's place and preside over the meetings.

All the metallurgists of Germany were glad to welcome the members of the Institute as their guests in Germany, and also to welcome the ladies who accompanied them. It was a very long time—34 years—since the Institute last visited Düsseldorf. The German iron and steel industries and the German metallurgists had tried to do everything in their power to make the present Autumn Meeting a great success.

He had the honour to transmit to the Institute the welcome of the Reichsminister and President of the German Reichsbank, who wrote:—

> "To my most sincere regret, it is impossible for me to be present at the meeting of the British Iron and Steel Institute, as had been my firm intention, inasmuch as urgent work keeps me busy here in Berlin. I wish your meeting the fullest and most cordial success, trusting that the remembrance of the close collaboration between the British and the German iron and steel industries, which has existed for so many decades, will animate this meeting also and strengthen on both sides the feeling that to-day more than ever international co-operation is necessary for the peace and welfare of all nations."—Hjalmar Schacht.

Continuing, Dr. Springorum said the programme of the meeting, in addition to the very interesting Papers which were to be read, offered the members the opportunity of visiting German works and seeing the best German practice. All the German iron and steel works without exception had agreed to allow members of the Institute to visit their plants, and that willingness could be regarded as a further token of a really hearty welcome. The metallurgists of Germany were very glad that the members of the Institute and their ladies would be given a further opportunity of becoming acquainted with the country and the people of Germany; they hoped that they would make the best use possible of that opportunity, and that in that direction also all their hopes and wishes would be fulfilled. It was his hope that the 1936 meeting of the Institute in Düsseldorf would continue profitably the meetings which the Institute had held there in 1880 and 1902. He was convinced that the present meeting would contribute to the renewal of old relations and to the creation of new ones, thereby strengthening still more the link which had existed for so long between the Iron and Steel Institute and the Verein deutscher Eisenhüttenleute. The metallurgists of Germany once again offered a hearty welcome to the visitors. They welcomed them with open hearts and wished their joint work every possible success.



Dr.-Ing. Otto Petersen.
(Honorary Secretary of the Reception Committee).

Dr. H. Wagenfuhr (Oberburgermeister of Düsseldorf) *(speaking in German)* offered a hearty welcome to the members of the Institute, who had returned to Düsseldorf after so long an interval, and a hearty welcome also to the ladies accompanying them. If it was true, he said, that political considerations sometimes separated the nations, there were two things which united them; sport and industry. So far as sport was concerned, this had been shown by the recent Olympic Games in Berlin; moreover, it was worthy of mention that every year English aviators came to Düsseldorf and, in return, German aviators were the guests of England. This spirit was continually developing. Sport and industry led to competition, but this competition was governed by the ideas of fair play, and was useful in promoting the well-being of peoples and their technical development, and in renewing good relations between them. Düsseldorf was not only a beautiful but also a progressive town, and he hoped the visitors would enjoy their stay, and that as many of them as possible would return for the Fair, which was to be held in the spring of 1937.

Dr.-Ing. Fritz Springorum
(Chairman of the Reception Committee).

Acting President's Reply

Mr. James Hendenson (Acting President of the Institute), in returning thanks for the welcome extended to the visitors, said that the President, Sir Harold Carpenter, had been forbidden to travel at the present time, but fortunately he was not seriously ill; it was more a matter of inconvenience. He had received the following letter from Sir Harold:—

> "To my very great disappointment, I am precluded by doctor's orders from presiding at the Autumn Meeting of our Institute in Düsseldorf. Lady Carpenter and I had been anticipating this with feelings of great pleasure. To me the occasion would have been one of extreme interest, because I had been looking forward to renewing my associations with Germany, where I came as a young graduate from the University of Oxford forty years ago to carry out a period of further study at the University of Leipzig. I stayed there for nearly two years, and after working out my *Arbeit* was awarded the degree of Doctor of Philosophy. During that period I made many friendships among both German professors and students, and I always feel that I owe much to

Studies of Casting Stresses in Chilled Iron Rolls

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5 Report of Sub-Committee XV, Committee A 3 on Impact Testing. Proceedings American Society Testing Materials, vol. 33, part 1, 1933.

6 A. E. Boye, "Strength of Materials," p. 16. McGraw-Hill Company, New York.

the scientific inspiration I obtained at that time of my life."

"Will you be so kind as to apologise to our hosts and to say how deeply I regret that I am prevented from meeting them and participating in the hospitality which they are so generously providing? I feel we are particularly indebted to those of our German members who are contributing Papers to this meeting. Will you also kindly give a message from me to those of our members who are participating in the meeting? Under your guidance I am sure it will be a very happy one. . ."

"In apologising to them for my unavoidable absence, will you kindly give them my warmest greetings and best wishes for a most enjoyable meeting?"

Continuing, Mr. Henderson said he thought it would be a graceful act if a message were sent to Sir Harold regretting his absence and wishing him speedy return to complete health. If that were the wish of the meeting, perhaps Dr. Petersen and Mr. Headlam-Morley would arrange for such a message to be sent.

He (the speaker) said he was overwhelmed by the messages of welcome which had been received. He would first refer to the very kind and thoughtful message from the Minister for Economic Affairs, Dr. Schacht. The members of the Institute appreciated very much the kind thought behind that message, and their best thanks would be conveyed to Dr. Schacht in due course.

It would be quite impossible for him to express the feelings of gratitude which the members had already formed for the reception that they had had, and that they knew they would continue to receive. Those of them, to the number of some 260, who came by the special train the previous evening were impressed by the perfection of the arrangements made for their reception at Aachen and beyond. Everything went smoothly, and after a good rest the members had assembled for the present meeting only some twelve hours after arriving in Germany. That, he was sure, was only a token of the perfection of the arrangements which had been made for their reception; and, in view of the programme before them, he was sure they would all go away full of admiration for the wonderful powers of organisation of their hosts.

He had been especially impressed by the great gathering which he was addressing that morning. There were many present who were known to him as members of the Iron and Steel Institute, and there were, of course, some members of that Institute of German nationality; but he felt sure there were many present who were not members of the Institute and who were probably members of the Verein deutscher Eisenhüttenleute. He regarded it as a great compliment that members of that body should be present and take an interest in the proceedings, and on behalf of the Institute he thanked them most heartily for their attendance and hoped that as far as possible they would contribute to the discussion of the Papers.

As Dr. Springorum had said, it was now 34 years since the Institute last met in Düsseldorf. He had had the pleasure of taking part in the gathering of 1902 as a member of the Institute, and he looked back on that meeting with great pleasure. To the Oberbürgermeister, he would say that no words of his could sufficiently praise the beautiful city of Düsseldorf. He first visited it half a century ago. He had paid many visits since that time, but always his early recollections had been confirmed and strengthened, and he firmly endorsed what had been said as to its progressive character. On behalf of the members of the Iron and Steel Institute, he thanked Dr. Springorum and the Oberburgermeister most sincerely and heartily for their welcome.

Dr. Springorum then vacated the chair, which was taken by Mr. James Henderson.

Dr. Springorum then proceeded to give his Paper entitled "Technical Developments in German Iron and Steel Production during the last Fifteen Years."

The Chairman, on behalf of all those present, thanked Dr. Springorum very warmly for the Paper he had presented. The author, he said, was the distinguished son of a very distinguished father, and had given the members that morning, out of the fullness of his knowledge, a very full and frank presentation of the progress of the iron and steel industry in Germany during the last fifteen years, and had thus afforded them a great deal of matter for consideration when they left Düsseldorf and returned to their own country. He was sure they would wish to accord Dr. Springorum a very cordial vote of thanks.

The vote of thanks was carried with acclamation.

The Chairman intimated that the formal business of the meeting would then be taken.

The minutes of the previous general meeting were taken as read and confirmed.

Dr. J. C. Hudson and Mr. E. C. Evans were appointed scrutineers of the ballot for the election of members, and at a later stage it was announced that all the candidates had been duly elected.

The Secretary (Mr. K. Headlam-Morley) announced that the following officers and members of Council would retire by rotation at the next Annual Meeting:—

Vice-Presidents: Mr. C. E. Lloyd, Dr. W. H. Hatfield, Sir William J. Larke, K.B.E.

Members of Council: Messrs. E. J. George, J. S. Hollings, W. J. Brooke, F. Clements, J. E. James.

The Chairman said it gave him much pleasure to announce that the Council had nominated Mr. Alfred Hutchinson to be the next President of the Institute. Mr. Hutchinson would therefore take office in May of 1937. He was an old and valued member of the Institute, which he joined in 1895.

The meeting then proceeded to the discussion of Papers.

In the afternoon some of the members visited the Kaiser-Wilhelm-Institut für Eisenforschung, and in the evening were entertained at a banquet in the Tonhalle by invitation of the Reception Committee.

THE BANQUET

The toasts of "His Majesty the King" proposed by Dr.-Ing. Springorum and "Der Führer und Reichskanzler" proposed by Mr. James Henderson, acting President of the Institute, were received with musical honours.

The following message from the Führer was read, and was greeted with applause:—

"I thank the English and German representatives of the iron and steel industry most sincerely for their greetings, and I reciprocate them with my best wishes for the success of their joint meeting. Adolf Hitler."

Dr. E. Poensgen, proposing the toast of "The Iron and Steel Institute," said that to have the honour of the visit of the British Iron and Steel Institute, among whose members the names of all the glorious pioneers of the steel industry had figured, was indeed a great distinction and delight to their fatherland. The close collaboration between them sustained a heavy shock during the Great War. The strands had now been taken up again, but that was the first occasion since the war that one of the Institute's important Autumn Meetings had been held in Germany. It was therefore a great honour to welcome, in the name of the Verein deutscher Eisenhüttenleute, the Institute to the iron city of Düsseldorf, which might well be called the industrial centre of Germany. It was there in Düsseldorf that the German industry had its technical centre, its scientific centre, in the Institute which had been visited that afternoon, and its economic centre, where all the work in connection with the domestic and international cartels was done.

Further, the speaker extended to the ladies a most hearty welcome to the garden city on the banks of the Rhine. He hoped they in Germany would succeed in making the visitors' stay an agreeable and memorable event. He trusted that in the short time available they would so learn to know and esteem one another that their acquaintanceship would develop into lasting friendship, which would lead towards a better and more complete understanding between the new Germany and the people of Great Britain. Germans who were engaged in the steel trade had always regarded their British colleagues with great admiration and respect, and were delighted by their visit. He asked his *confrères* to raise their glasses and to drink to the development and future progress of the British Iron and Steel Institute.

The toast was received with enthusiasm.

Mr. James Henderson, replying, said at the outset that he had received a telegram from Sir Harold Carpenter, in response to the message which they sent him that morning, thanking them for the telegram, which Lady Carpenter and Sir Harold had much appreciated. They hoped the meeting would be a great success.

Continuing, the speaker said that Dr. Poensgen had very eloquently wished the Iron and Steel Institute the greatest success, and he was happy to say that their Institute was definitely going from strength to strength, and a good deal of the credit for that was due to their able Secretary, whom he would take the liberty of naming, Mr. Headlam-Morley. He was undoubtedly helping the Institute very much indeed by his youth, vigour and new ideas. They were proud to think that their Institute was of an international character. They did not always realise that they had more than six hundred members outside the British Empire, spread over some twenty-four countries, in which nearly every country in Europe was included, and they also had members in Asia, in North and South America and even in Africa. They felt, therefore, that the Iron and Steel Institute of Great Britain was a nucleus round which they might hope to crystallise a great deal of that desire for co-operation which they felt was rampant, one might almost say, throughout the world.

He had no wish to enter upon an economic discourse, but it was very sad that so many countries—and Great Britain could not be excepted—were trying to be self-sufficient. It was an old saying that it would be a poor life if we tried to live by taking in each other's washing; the standard of life would not be a very high one. That, however, was the tendency in every country to-day, and it was for Institutes of that kind, including commercial organisations also, to do what was possible in these very difficult circumstances to get together. He wished to thank Dr. Poensgen for the way in which he proposed the toast, and those present for the cordial way in which they had received it.

Mrs. Henderson, who was received with prolonged applause, briefly replied on behalf of the ladies.

Mr. Alfred Hutchinson said that he wanted in a single sentence to thank Dr. Springorum for presiding in so charming a way over their meeting that morning. Last time the Iron and Steel Institute met in Düsseldorf he (the speaker) had the great pleasure of being there, and he had always associated Dr. Springorum's name with the fact that all that time ago he met his father, who was one of the great captains of German industry with whom he associated that visit. It was a great pleasure to come to Düsseldorf again so many years later and be under the presidency of his son, Dr. Springorum. He proposed that they tender to Dr. Springorum their best thanks for the way in which he presided over the reception meeting that morning.

Apart from the meeting on Tuesday which was held jointly with the Verein deutscher Eisenhüttenleute, the members visited a large number of works in the Ruhr. In addition to other functions on Friday evening, the visitors were entertained by Herr Dr. Krupp von Bohlem und Halbach at the Villa Hügel. On Saturday there was an excursion to Rüdesheim and Coblenz, the journey being partly accomplished by Rhine steamer.

Controlled Grain Size in Steel*

By T. SWINDEN and G. R. BOLSOVER

(Abridged.)

The authors consider that the subject of controlled grain size in steel has not received the recognition in this country which it deserves, and have presented tests on a selection of steels made specially to demonstrate the difference in physical properties between relatively coarse and fine grain on the *same cast* of steel.

Eighteen types of steel are used in the work described in the Paper, in which the only variable within practical limits is the grain size. Inherent grain size is a characteristic of the steel controllable as a function of steelmaking. It is shown that fine-grained steel, compared with coarse-grained steel of precisely similar quality, has certain well-marked differences in physical characteristics, and that where the engineer desires a better Izod value with a given tensile strength, or conversely a somewhat higher tensile strength with a given Izod value, it is advisable to consider the possibility of achieving the objective by a study of controlled grain size as an alternative to the use of a more highly-alloyed steel.

While the main objective of the Paper is to place facts based on an extended experience before the reader, some views are expressed on the fundamental theory underlying the process of manufacturing steel of controlled grain size. It is suggested that inherent grain size is a function of the ultimate degree of deoxidation during steel manufacture. We append some extracts from the Paper giving the authors' method of controlling grain size and some notes on the underlying theory, together with their conclusions.

The authors state that the principles involved in the production of controlled-grain-size steel depend in some way upon the method used for deoxidation. When making a thoroughly deoxidised steel, the usual procedure is to add progressively, and in suitable amounts, manganese, silicon and aluminium, based on the theory that these metals react with the dissolved FeO, which reactions result in deoxidation products. It is agreed that in the desire to produce steel as free from non-metallic inclusions as possible, the steelmaking practice should be such that these deoxidation products are removed from the steel to the maximum possible extent before the steel solidifies in the ingot mould.

Theory of Aluminium Additions

Aluminium was originally regarded (with justification) as a corrective for over-oxidation resulting from badly-worked casts of steel. It was associated with the view that the resulting steel was less satisfactory and almost invariably "dirty."

The authors show that, on the contrary, aluminium may now be regarded as a very valuable agent for the improvement of the physical properties.

The early antipathy to the use of aluminium was, no doubt, well founded, but it can confidently be asserted that if steel is properly made, aluminium can be used for the purpose of producing the desired inherent grain size without increasing the content of non-metallic inclusions.

The original theory put forward in America, and still common in technical literature, is that fine grain is achieved through the agency of minute particles of alumina distributed throughout the steel. Thus, it is suggested that the increase in the number of nuclei promoting crystallisation results in the production of the fine austenitic grain. It follows from this theory that it is essential that the steel shall be made under carefully-controlled conditions, so as to obtain the proper degree of deoxidation by manganese and silicon prior to the addition of aluminium. If, for example, aluminium be added to a bath containing very much iron oxide, then aluminium is wasted in the preliminary deoxidation, and the resulting alumina is so coarse as to rise in the liquid steel instead of forming the desired nuclei.

The authors have never been quite satisfied with this theory, and they therefore read with interest the Paper by McQuaid, in which he examines it more critically. He expresses doubt as to the validity of the nuclear theory, and tentatively suggests an alternative theory based on the effect of the aluminium (beyond that required for deoxidation) on the coalescence of the carbides precipitated when the austenite transforms. Several facts are presented which appear to render the nuclear theory untenable. For example, it is shown that in comparing fine- and coarse-grained steel, the content of alumina is fairly constant, whilst there are invariably striking differences in the aluminium content, although absolute accuracy is not claimed for the values of the aluminium and Al_2O_3 respectively.

The authors have made a thorough examination of three types of steel, made respectively in the fine- and coarse-grained condition, from the same cast. Aluminium and Al_2O_3 were determined by direct solution in HCl, and the non-metallic inclusions were separated by the iodine extraction method and analysed. Considerations of space preclude the inclusion of all the data, but briefly it may be said that there is no essential difference in the Al_2O_3 content between fine- and coarse-grained steel. The *aluminium* content is greater in the fine-grained steel, the values ranging from 0.020 to 0.030 per cent. in these tests, as against traces of the order of 0.001 to 0.007 per cent. in the coarse-grained. It does not follow, however, that the excess aluminium *per se* is the vital controlling factor.

A wide experience in observing the manufacture of fine-grained steel in the basic and acid open-hearth and the electric furnace leaves the authors with the impression that the essential principle is associated with *the degree of oxidation of the resulting steel.*

None of the methods yet available can tell us the oxygen content of the steel, apart from (or in addition to) that existing as non-metallic inclusions. When we are completely satisfied, state the authors, with the vacuum fusion method for *total* oxygen and the iodine extraction (or other) method for the oxygen *in the inclusions*, we may be able to arrive at this important value.

From the above, it is hardly necessary to say that, in the authors' considered opinion, the production of controlled-grain-size steel consists of much more than simply adding a certain amount of aluminium or other deoxidiser. It requires a carefully considered and worked out technique, according to the steelmaking process, the type of steel being produced, and the purpose for which it is intended. It is for this reason that detailed information concerning the steel manufacture has not been included, as this might in fact be misleading to other steelmakers, who would not be conversant with all the factors involved.

It would not be out of place, however, to point out that the control of grain size imposes a further burden on the steelmaker. It has been emphasised that fine-grained steel can be produced only when a procedure is followed which results in thoroughly deoxidised steel. It necessarily follows that fine grain cannot be produced in rimming steel or semi-killed steel.

Over-Reduced Steels

Reference has been made from time to time to certain characteristics related to over-reduced steel, and a little consideration will show that the highest degree of skill is necessary in producing fine-grained steel which is free from the well-known drawbacks of over-reduced steel, with particular reference to the latitude in temperature control during casting.

The fact remains, however, that these steels are now commercially available, and the improvement in physical characteristics that has been clearly demonstrated in this Paper has warranted, in the authors' opinion, the intensive work which has been necessary in overcoming the difficulties that the procedure would tend to involve.

Summary and Conclusions

A specimen of fine-grained steel, compared with coarse-grained steel of precisely similar quality, has certain well-marked differences in physical characteristics. Very briefly, these may be summarised as: (*a*) Greatly enhanced toughness as judged by the Izod (notched-bar) test, with particular reference to plain medium-carbon and low-alloy steels; this results in a more dependable and uniform product. (*b*) A less, but still beneficial, effect on higher-alloy steels, with particular reference to certain types of brittleness. (*c*) In mild steel, quench-ageing is not accompanied by any reduction in toughness, whilst the reduction in toughness by strain-ageing is very considerably reduced. (*d*) The use of steel of controlled grain size facilitates heat-treatment and also, in the authors' view, renders standardisation of machine-shop practice more certain and reliable. (*e*) The authors concur in the view of the American observers that the use of aluminium in producing fine grained steel does not increase the number of deleterious non-metallic inclusions.

The relative effect of heating on grain size is illustrated and some thoughts are expressed on the underlying theory concerned. The authors do not consider that the "sub-microscopic alumina nuclei" theory meets the facts, and they doubt whether the later suggestion by McQuaid—*viz.*, the effect of aluminium (beyond that required for deoxidation) on the formation of ferrite from austenite and the coalescence of the carbide—is entirely satisfactory. They incline to the view that the underlying fundamental concerned is the ultimate degree of deoxidation.

Finally, in what way should this subject of grain-size control interest the engineer? In other words, what are the practical implications of this work from the user's point of view? It might be questioned whether, if a specification is considered to represent, and is shown by experience to be justified in representing, the supply of an adequate quality of steel, it is necessary for the purchaser to add to the difficulties of the steel supplier by specifying grain size control, and to himself by ensuring that he gets it? This, the authors imagine, is the question that any prospective user will ask himself. The reply is that herein lies a means of ensuring a more regular type of product, with, particularly in the case of the straight carbon and low-alloy steels, a definite improvement in toughness (as represented by the Izod test). This is an alternative, within limits, to the addition of an increased content of alloying elements, which may be comparatively expensive and which almost certainly adds to the difficulties of manipulation and heat-treatment, as well as, in some cases, complications connected with such items as flame cutting and welding.

The information contained in this communication also indicates that, whereas without grain-size control the size in which certain types of steel could safely be used is limited, such limits are greatly extended when fine-grained steel is employed.

It is quite unnecessary to make any exaggerated claims for fine-grained steel, but the authors do consider that grain-size control is of fundamental importance, and they submit that if and when cases arise where the engineer desires a better Izod value with a given tensile strength, or, conversely, a somewhat higher tensile strength with the same Izod value, he would be well advised to consider the possibility of achieving the objective by a study of controlled grain size as an alternative to the use of a more highly alloyed steel.

* Paper presented at the Autumn Meeting of the Iron and Steel Institute in Düsseldorf.

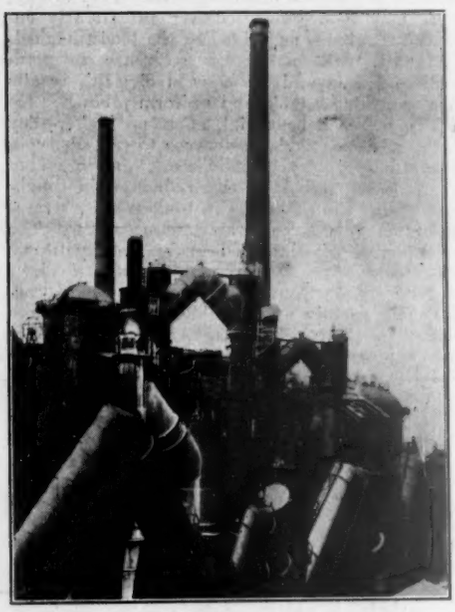
Works of the Halbergerhütte, Saar

Among the works which were visited by some members during the Autumn Meeting of the Iron and Steel Institute held in Düsseldorf last week were those of the Halbergerhütte G.m.b.H., Brebach, Saar, one of the principal manufacturers of castings in that district. Its existence dates back to 1431. Operations in the manufacture of various iron products by the crude processes then current continued until 1756, when Count Wilhelm-Heinrich von Nassau-Saarbrücken reconstructed the ancient works at Oberbrebach for smelting and forging. For over a century the Brebach works then manufactured both wrought- and cast-iron wares, particularly wagon axles.

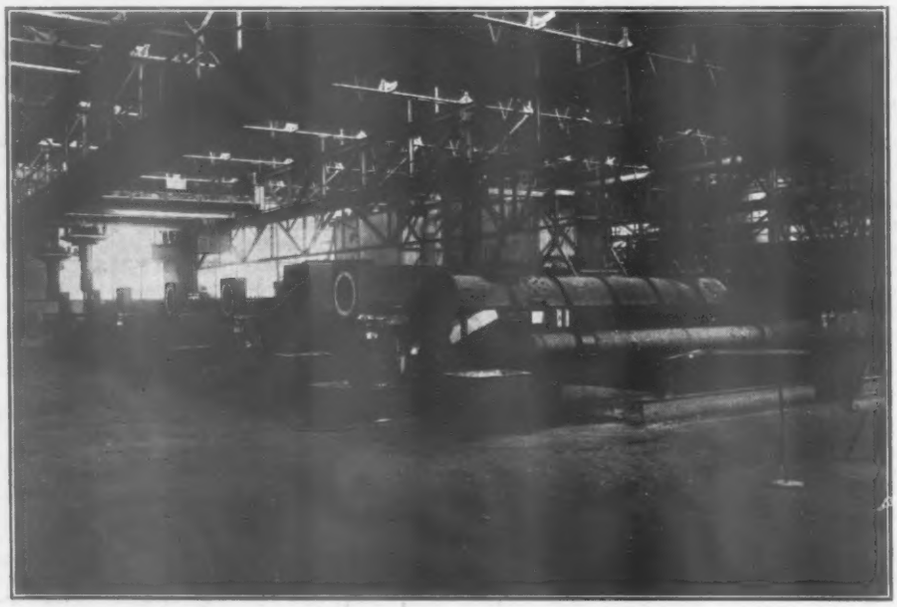
At the beginning of last century the supplies of wood in the neighbouring forests became exhausted, as well as the supply of iron ore in the Saar, which together caused the complete transformation of the raw-materials supply of the Saar iron and steel industry. After many difficulties, a new basis of raw materials was provided by the introduction of minette ores from Lorraine and their smelting with coke made from Saar coal. These developments led to the construction of new railways and canals and laid the foundations of the Saar iron and steel industry of the present day. The Halberg concern moved with the times and reorganised its works to meet the altered conditions. An entirely new works was erected adjoining the old works, for the manufacture of cast pipes, and in 1869 a blast furnace with hot-blast stoves and a large foundry were put into production. Initially the pipes were made in vertical moulds, the products of the foundry also including pipe fittings and all standard commercial castings.

With the starting-up of the new plant and the entering of a new sphere of activity, the period of rapid expansion of the Halberger concern to its present important position was inaugurated. The works plant has been steadily enlarged and the range of products has continually become more diverse to meet current needs. To-day, the works have seven blast furnaces, the last of which was erected in 1927.

In various directions the Halbergerhütte have been pioneers in the Saar. It was the first industrial concern to recover the by-products from its coke-oven plant (1890), and to supply gas through long-distance transmission mains to Saarbrücken, in 1900. It also originated dry gas cleaning with Beth filters (1911), and more recently was the first to erect the most up-to-date high-capacity coke ovens (1927) in the Saar.



View of Blast-Furnace Plant.



Part of the Pipe-Spinning Department.

In 1923 a tar-distillation plant was built to process the tar from the coke ovens.

The pipe-making process has been altered in the course of time to keep manufacturing practice abreast with current invention. The Halberger works were thus the first Continental works to introduce in 1931, after a long period of experimental work, the centrifugal-casting process. Simultaneous with developments in pipe manufacture, the range of operations of the foundry has also been expanded, so much so that the old one was replaced in 1929-30 by an entirely new foundry with the latest conveyor equipment. The new foundry section is claimed to be one of the best-planned and best-equipped on the Continent.

Conveyor Equipment in the Mechanised Foundry.

Oxy-Acetylene Welding

The publication of B.S.S. No. 693: Oxy-Acetylene Welding as applied to Steel Structures, makes a further addition to the series of B.S. Specifications relating to welding that are now available. The new publication is complementary to B.S.S. No. 538, which was issued in 1934 for the metal arc welding of steel structures, and accordingly follows the same general lines. It includes, amongst others, requirements for the methods of making the joints, the maximum working stresses to be permitted, the workmanship and flame conditions to be maintained and the tests to be carried out on welded joints. In the absence of a B.S. Specification governing the quality of welding rods for oxy-acetylene welding appropriate requirements have been included, whilst the methods of making the test-pieces and of carrying out the tests on both weld joints and on all-weld-metal test-pieces are also described separately. Copies of this Specification (No. 693—1936) may be obtained from the Publications Department of the British Standards Institution, 28, Victoria Street, London, S.W.1. (Price 2s. 2d. post free.)

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Melting Furnaces for Malleable Cast Iron

The Exchange Paper presented on behalf of the Russian Foundrymen's Association to the Detroit meeting of the American Foundrymen's Association was written by Mr. N. G. Girshovitch and Mr. A. F. Landa. The range of their experiments covered the operation of hand and pulverised-fuel fired air furnaces, the open-hearth, both basic and acid electric, the cupola, the Brackelsberg, and duplexing processes involving the cupola and acid and basic electric, the air furnace and a rotary oil-fired plant. The authors have drawn the following conclusions as a result of their researches:—

(1) Investigations on the effect of type of melting unit on the properties and the rate of graphitisation of malleable iron have shown the evident advantage of the rotary Brackelsberg furnace. The poorest results were obtained when melting in the basic electric furnace with cold charging.

(2) The effect of melting in any of the furnaces—cupola, basic and acid duplexing process, air furnace and acid electric furnace—is comparatively small, and probably depends upon the method of executing the process. The opinion mentioned in literature, that the graphitisation of malleable iron melted by basic duplexing process is slower than the material obtained by other processes, was not confirmed by the authors' tests.

(3) The effect of type of melting furnace upon the mechanical properties and the rate of graphitisation of malleable iron is determined chiefly by the quantity of oxygen and gases in the metal.

(4) The quantity of oxygen and gases in the metal is determined not only by the character of the equipment but chiefly by the method of carrying on the process in a given furnace.

(5) A decrease in oxides and gases in the metal leads, in the opinion of the authors, to an increase of strength and ductility of the metal.

(6) The time necessary for the first stage of graphitisation is considerably shorter than the time used in practice, and even under the least favourable conditions should not exceed 10 hrs. at 975 deg. C.

(7) The rate of graphitisation in the first and second stages probably depends upon the content of oxides and gases in the metal, an increase of this content decreasing the rate of graphitisation.

(8) Slow cooling of malleable iron castings in the sub-critical temperature interval contributes to increased ductility of the metal.

(9) Brittleness and white fracture in malleable iron are related to the content of oxides and gases in the metal, which causes and facilitates this phenomenon.

(10) Deoxidation of metal diminishes its liability to white fracture and increases the ductility of malleable iron.

(11) To attain final improvement of the manufacturing of malleable iron and to secure constant standard qualities, it is necessary to introduce into practice the control of oxygen and gas content in malleable iron.

(12) The effect of oxygen and gases in malleable iron should be made an object of special investigation.

(13) With regard to the temperature of liquid metal, all melting units may be divided into three groups:—electric furnaces, air furnaces, and cupolas.

(14) Malleable iron of lowest cost is obtained by melting in the cupola. The following is the sequence with regard to production cost: (i) combination of cupola with air furnaces, (ii) air furnaces and open-hearth furnaces, (iii) duplexing process—cupola and electric furnace, (iv) the cost is highest for malleable iron melted in electric furnaces with cold charging.

(15) Small changes in the order of the sequence scheme given in (14) are possible with fluctuations in prices for steel scrap, pig-iron, fuel, and electric energy.

(16) On the basis of economic analysis and investigation work effected by the Central Institute of Scientific Research of Machine-Building, the installation of one or another type of equipment may be recommended in the following conditions:

(*a*) *Cupola*—for less intricate castings when requirements for mechanical properties are not so severe, in comparatively small and medium sized foundries with short distances between cupola and moulds and with direct transfer of liquid metal from cupola to ladle and then to mould, without intermediate transfer.

(*b*) *Duplexing process*—cupola and air furnaces for intricate and thin-walled castings with relatively high mechanical properties in mechanised foundries. The installation of small, rotary, oil-fired furnaces may be specially recommended in such conditions as this considerably facilitates transport and reduces waste due to misrunning.

(*c*) *Air furnaces, including Brackelsberg furnaces*—in small and medium-sized foundries for high-duty castings when the cost of pig-iron is low and that of steel scrap is high.

(*d*) *Open-hearth furnaces*—in the same conditions as mentioned for air furnaces, in combined foundries for malleable iron and steel castings.

(*e*) *Duplexing process; cupola and electric furnace*—in large mechanised foundries for high-duty and very intricate castings with specially high strength requirements, provided the prices for scrap are low, and iron costs are high. A basic lining may be used only in the case of high sulphur coke.

(*f*) *Electric furnaces with cold charging*—in non-mechanised foundries for very intricate castings liable to hot tears, provided the prices for electric energy, scrap, borings and turnings are very low.

Publications Received

Standard Methods of Analysis of Iron, Steel and Ferro-Alloys. Revised and enlarged edition. Published by the United Steel Companies, Limited, 17, Westbourne Road, Sheffield, 10. Price 4s. 6d.

This book which was first published in 1933 was excellently received throughout the industry and as a result the first edition has become exhausted. The new edition has undergone a thorough revision and contains fourteen additional methods of analysis, including the determination of vanadium, titanium, copper, aluminium and zirconium in alloy steel, together with the estimation of tungsten, molybdenum, vanadium, titanium and chromium in their respective ferro-alloys. Owing to the increasing use of special elements in cast iron, this book now has a special value to metallurgists attached to grey iron foundries. With the additions the book is well worth the very modest price.

The Use of Abrasive Wheels. 5th Edition. Published as Home Office Safety Pamphlet No. 7 by H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. Price 9d. net.

The fact that this booklet has now reached its fifth edition is an excellent testimony as to its worth to industry. The information given in its fifty odd pages is of a definitely utilitarian character and is extremely useful to those responsible for the conduct of the fettling shop. It certainly should be possessed by every foundry organisation in the land, as no other book covers quite the same ground so authoritatively.

Medallions Cast in Manganese Steel

Amongst the exhibits of Hadfields, Limited, Sheffield, at the Empire Exhibition at Johannesburg are two medallions cast in Hadfield's manganese steel and reproduced herewith. One of these medallions represents H.M. The King which he saw cast and on the mould of which he stamped his signature when as Prince of Wales he visited Hadfields' works some years ago. The other medallion represents General the Rt. Hon. J. C. Smuts, P.C., the Honorary President of the Empire Exhibition. A few days before the

MEDALLION OF H.M. KING EDWARD VIII WHEN PRINCE OF WALES, CAST IN MANGANESE STEEL.

opening of the Exhibition Sir Robert Hadfield cabled General Smuts as follows:—

"On behalf of myself and the other directors of my company I beg to offer you as Honorary President and your colleagues our heartiest good wishes for the great success of this wonderful Empire Exhibition at Johannesburg. I trust you will like your portrait in the cast medallion of manganese steel presented in our exhibit in Hall L of heavy machinery."—HADFIELD.

MEDALLION, 20 IN. DIAMETER, OF GENERAL THE RT. HON. J. C. SMUTS, P.C., CAST IN MANGANESE STEEL.

The definition in these small castings of manganese steel is remarkable. The temperature of the fluid metal would be about 1,450 deg. C. so that no ordinary sand as used for cast-iron castings would be of the slightest service, a special and highly refractory moulding material having to be employed.

FOR STRONG CASTINGS WHICH MACHINE PERFECTLY

WHY WORKINGTON IRONS EXCEL

POINT No. 3

THE UNITED STEEL COMPANIES LTD

•LOW SULPHUR•

Workington Irons are low in sulphur. For strong castings and jobs where a good surface is essential, sulphur **in the finished casting** should be kept below 0·12%—preferably about 0·08%. This reduces the liability to chill and minimises brittleness at corners and in thin sections like the fins of motor cycle cylinders.

The low sulphur content of all Workington Irons counteracts sulphur pick-up from the coke in the cupola, and from admixed scrap.

Special low sulphur and low phosphorus grades are available, from (S. and P. .02% max.) upwards.

WORKINGTON IRON AND STEEL COMPANY, WORKINGTON, CUMBERLAND
Branch of The United Steel Companies Limited

WORKINGTON West Coast Hematite PIG IRONS

W 23

The Week's News in Brief

Trade Talk

THE REGISTERED OFFICE of the Coltness Iron Company, Limited, is now at 36, Robinson Street, Glasgow, C.2.

THE FRENCH FOUNDRY TECHNICAL ASSOCIATION is to organise the next International Foundry Congress, which will be held in Paris from June 17 to 23, 1937.

THE NEW MOTOR VESSEL "Lairdsbank," which has been built by Harland & Wolff, Limited, of Belfast, for the Burns & Laird Line, has completed successful trials at Skelmorlie.

THE ADDRESS OF Clifford Christopherson & Company, Limited, on and after October 12, will be Shell-Mex House, Strand, London, W.C.2. The new telephone number will be Temple Bar 7711.

AIR AND GAS COMPRESSORS and back-pressure steam engines for a variety of applications figure largely amongst recent contracts obtained by J. Browett Lindley (1931), Limited, power-plant manufacturers, of Letchworth, Herts.

EXTENSIONS ARE BEING MADE at the Parkhead Works, Glasgow, of William Beardmore & Company, Limited. A new planing machine capable of operating on armour plate, weighing from 25 to 45 tons, is being installed.

UNDER AN AGREEMENT with the Czecho-Slovak Iron and Steel Cartel, the Zopetauer & Stefanauer Iron & Steel Company has agreed to close down its rolling mills for ten years, in return for an annual indemnity of 400,000 cr.

THE SUNDERLAND FORGE & ENGINEERING COMPANY, LIMITED, are moving their London offices into new premises in Creechurch Lane, E.C.3, and as from September 29 their address will be Creechurch House, Creechurch Lane, London, E.C.3.

THE WHITWORTH SOCIETY OF GREAT BRITAIN held its annual meeting in Newcastle-upon-Tyne recently. Visits were paid to the North-Eastern Marine Engineering Company's works at Wallsend and the South Benwell works of Michell Bearings, Limited.

AN EXHIBITION OF "STAYBRITE" steel articles in the showrooms of Wilks Bros. & Company, Limited, Utility House, Exchange Street, Sheffield, was opened on Friday, September 18, by Mr. A. J. Grant, chairman of Firth-Vickers Stainless Steels, Limited.

THE IMPROVEMENT in the light-castings industry is shown in the six-months' report of the Ironfounding Workers' Association presented by Mr. Hugh Murdoch recently. Since the beginning of the year membership has increased by 267, bringing the total to 9,833.

SIR JOHN JARVIS, M.P., has taken over the old boiler shops at Jarrow originally owned by the Palmers Shipbuilding & Iron Company, Limited, for conversion into metal works. The works will manufacture metal under a German patent, but with British capital.

A FIRE WHICH OCCURRED on September 26 destroyed the roof of the enamelling shop of the Falkirk Iron Company, Limited. As a result a number of women employees will be unemployed for a few days. Arrangements are being made to carry on business as usual.

THE COMMONWEALTH & DOMINION LINE have ordered three vessels of 9,500 tons on the North-East Coast, comprising one each from Swan, Hunter & Wigham Richardson, Limited, Wallsend, William Doxford & Sons, Limited, Sunderland, and J. L. Thompson & Sons, Limited, Sunderland.

S. A. JOHN COCKERILL, Seraing, Liége, report a gross profit of 90,000,000 fcs. and a net profit of 35,000,000 fcs. in the financial year ended June 30 last. It is proposed to carry the whole of this sum to amortisation account. No profits were shown in 1935 and 1934, and no dividend has been paid since 1930.

THE HAUTS-FOURNEAUX DE LA LOUVIÈRE report an increase in net profit from 1,506,000 fcs. in 1934-35 to 3,600,000 fcs. in the past year; the credit balance on June 30 was 4,800,000 fcs., permitting the payment of a net dividend of 50 fcs. per share as compared with 25 fcs. in 1934-35. Orders on hand are sufficient for several months.

WILD-BARFIELD ELECTRIC FURNACES, LIMITED, of Elecfurn Works, North Road, Holloway, London, N.7, have prepared a series of lantern slides illustrating many types of electric furnaces for heat-treatment, together with notes regarding the various slides. Notes and lecture are available for societies, technical schools or other interested bodies. As the number of sets is limited, early intimation that they are required would assist in ensuring that they will be available.

THE LORD MAYOR and Lady Mayoress of Sheffield were present on September 17 at the opening by Lord Riverdale of Genefax House, Tapton Park Road, Ranmoor, as the new headquarters of the administrative staffs of General Refractories, Limited, who have been transferred from premises at Wicker Arches. The guests were welcomed by Mr. Frank S. Russell, chairman and managing director of the company, and Mrs. Russell. Mr. Russell said they had done their best to preserve the amenities at Ranmoor. Since 1920 their business had expanded to such an extent that its monthly sales were now ten times what they were in those days.

Contracts Open

Bilston, October 6.—1,625 yds. of 6-in. cast-iron water mains, for the Town Council. Mr. J. L. Arlidge, town clerk, Town Hall. (Fee £2 2s., returnable.)

Kidderminster, October 5.—3,950 yds. of 3-in. cast-iron pipe water main, for the Rural District Council. Fiddian & Deeley, engineers, 13, Church Street, Stourbridge. (Fee £3 3s., returnable.)

Cairo, November 24.—Hydro-electric station, comprising four units: two 1,000-kw. each and two 330-kw. each; three electric driven pumping stations, each comprising four units; double circuit 33,000 volts, three-phase overhead transmission line 90 km. long and having conductor section of 25 sq. millimetres; three Diesel driven pumping stations, each comprising four units, for the Director-General, Mechanical and Electrical Department, Ministry of Public Works, Cairo. The Chief Inspecting Engineer, Egyptian Government, 41, Tothill Street, London, S.W.1. (Fee £E.5 plus 80 mills.)

Wellington, November 10.—Plate-bending rolls; screwing machine; forging hammers; universal milling machine; shaping machine; radial drilling machine; band saw for wood; engine lathe; muffle furnace, for the New Zealand Public Works Department. The Department of Overseas Trade. (Reference T. 2,040.)

Company Reports

Hopkinsons, Limited.—Interim dividend of 2½ per cent. on the ordinary shares.

Metal Industries, Limited.—Dividend on the 5 per cent. preference stock for the half-year ended September 30.

Vulcan Foundry, Limited.—Dividend on the ordinary shares at the rate of 2½ per cent. for the year ended June 30.

British Aluminium Company, Limited.—Dividend of 3 per cent. on the preference shares for the six months ended June 30.

Glenboig Union Fire-Clay Company, Limited.—No dividend is recommended; £423 forward, decrease £1,912, being loss for period of four months ended December last. Company having now become a subsidiary of General Refractories, Limited, accounts have been prepared to December to coincide with parent company's financial year.

Wellman Smith Owen Engineering Corporation, Limited.—Gross profit for 18 months to June 30 last, £28,190; loan interest and bank overdraft, £6,111; directors' fees, £1,950; net profit, £20,130; income tax, £2,190; profit realised prior to reconstruction and applied therein, £5,333; dividend of 5 per cent., £7,771; carried forward, £4,835.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Pollock Fireplace & Hardware Company, Limited, 67, Newhall Street, Birmingham.—Capital, £2,000. Directors: F. Coller and Mrs. M. K. Pollock.

Personal

MR. LANCELOT W. WILD, M.I.E.E., has retired from active participation in Wild-Barfield Electric Furnaces, Limited.

MR. DAVID SMART, SEN., a fitter with Low & Duff, Limited, iron and brass founders, of Albert Works, Monifieth, received a presentation from the staff when he retired recently.

MR. T. LAING is leaving J. Stone & Company, Limited, of Deptford, to take up an appointment as foundry works manager with John Hall & Sons (Oldham), Limited, of Oldham, Lancs.

MR. B. H. RILEY, sales manager of the engineering division of British Timken, Limited, Birmingham, is now on a visit to the United States. The object of his visit is to study the latest applications of anti-friction bearings.

PROF. FREDERIC BACON, head of the Engineering Department at Swansea University College, has been elected President of the South Wales Institute of Engineers for the year 1937, and will be formally installed at the January meeting.

Wills

FOOTE, JAMES, patternmaker, of Bawhirley Road, Greenock £1,046

NORRIS, FREDERICK AUBREY, chairman of F. A. Norris & Company, Limited, structural engineers and ironfounders, and Norris Warming Company, Limited, heating and ventilating engineers, of London £28,479

Obituary

MR. F. W. JAYNE, who retired five years ago from the position of manager at the Llanelly foundry of Richard Thomas & Company, Limited, died recently, aged 79.

MR. JAMES CUNNINGHAM, a member of the staff of the Carron Company's foundries for over fifty years, died at his home in Falkirk last Thursday. He was in his 80th year.

M. HENRY LE CHATELIER, inspecteur général des mines and honorary professor at the Sorbonne and the Collège de France, died recently, aged 86 years. Prof. Le Chatelier, who was appointed to his first chair in 1878, was one of the outstanding French workers investigating various problems relating to the safety of coal mines. His principal contributions to science in this field were researches dealing with the explosive properties of mine atmospheres containing inflammable gases and dusts. He also carried out pioneer work on the microscopy of metals and a variety of chemical problems. In recognition of his outstanding services to technological science he was elected to the Académie des Sciences in 1907, to fill the vacancy left by the death of Henri Moissan.

Forthcoming Events

Manchester Association of Engineers

OCTOBER 6-8.
Conference on Electric Lighting in Works and Offices, in Reynolds Hall, College of Technology.

OCTOBER 9.
Presentation of awards; Presidential Address by Mr. J. A. Thornton; concert at the Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

Institute of British Foundrymen

OCTOBER 7.
London Branch:—Presidential Address; cinema film by J. Stone & Company, Limited, at Charing Cross Hotel, Strand, W.C.2, at 8 p.m.

OCTOBER 9.
Middlesbrough Branch:—Presidential Address, at the Cleveland Scientific and Technical Institute, Middlesbrough, at 7 p.m.

OCTOBER 10.
Wales, Monmouth and West of England Branch:—Social, at the Royal Hotel, Cardiff, at 6.30 p.m.

The Institute of Vitreous Enamellers

OCTOBER 2-4.
Third Annual Conference, in Manchester.

OCTOBER 8.
Southern Section:—"Design of Metal and Cast Iron Parts for Vitreous Enamelling," Paper by J. H. Coupe, at British Industries House, Marble Arch, London, W.1, at 8 p.m.

ROWLAND

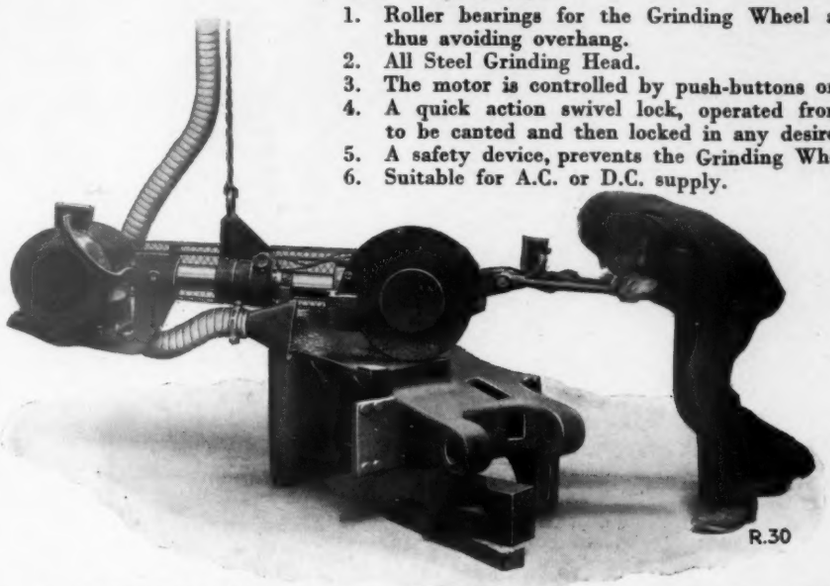
HIGH SPEED PORTABLE GRINDER

This is an entirely new High Speed Grinder, for fettling castings which cannot be handled.

It is quick and light to operate, yet sturdy, of build.

Exclusive features:

1. Roller bearings for the Grinding Wheel are located inside the Wheel collet, thus avoiding overhang.
2. All Steel Grinding Head.
3. The motor is controlled by push-buttons on the handle-bars.
4. A quick action swivel lock, operated from the handle-bars enables the Wheel to be canted and then locked in any desired setting.
5. A safety device, prevents the Grinding Wheel being run at an incorrect speed.
6. Suitable for A.C. or D.C. supply.



All foundries should have particulars of this new machine.

F. E. ROWLAND & CO., LTD., Climax Works, REDDISH, STOCKPORT

LONDON: H. C. Amos & Co., 22, Martin Lane, Cannon Street, LONDON, E.C.4
SHEFFIELD: Gregory & Taylor, Ltd., Howard Street, Sheffield.
LEEDS: H. Ormerod, Esq., Melbourne Street, Hebden Bridge, Yorks.
N.E. Coast: T. Feather, Esq., 16, Devonshire Place, Jesmond, NEWCASTLE-on-TYNE.
MIDLANDS: L. Williams, Esq., 31, Parkside, COVENTRY
SCOTLAND: Wilson Feather & Son, 122, Wellington Street, GLASGOW

WARNER Special PIG IRONS

- Warner C.B.R. and Low Carbon Cylinder
  (FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
- Low Carbon Malleable
  (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

Typical Cylinder Pig Iron Specification

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO. LTD
CARGO FLEET MIDDLESBROUGH

Raw Material Markets

It has been necessary to introduce a system of rationing in the distribution of supplies of pig-iron in order to ensure that all consumers receive material proportionate to their requirements. The demand shows no sign of abatement, and contracts for forward delivery are eagerly sought. Several ore ports in Northern Spain are closed, and this will inevitably affect supplies to this country in due course.

Pig-Iron

MIDDLESBROUGH.—Consumers of pig-iron in this area are having to be content with supplies which are only sufficient to allow them to maintain a normal rate of working, and under the system of rationing they are prohibited from building up stocks. This they would, of course, like to do, owing to the possibility of a shortage later on. Producers, however, anticipate that all home requirements will be fully satisfied. The position as far as the export market is concerned is not so promising, and only very small parcels are being despatched. Renewals of contracts may be made up to the end of March at current prices, which are based on No. 3 Cleveland G.M.B. at 75s. per ton in the Middlesbrough and Falkirk areas, 77s. on the North-East Coast, and 78s. in Glasgow.

The position of the East Coast hematite market is very satisfactory, and fair supplies are available. Exports have increased, and arrears of deliveries are being erased to some extent, although they still remain considerable. Production up to the end of the year is already accounted for, but some business can be transacted over the first few months of next year at current quotations.

LANCASHIRE.—Deliveries of pig-iron have shown a further expansion during the past week, and more active conditions generally are prevailing in this area. The chief sources of consumption continue to be the light-castings foundries, heavy electrical, machine-tool and general engineering establishments. New business has been transacted involving deliveries up to the end of March. Offers of Derbyshire and Staffordshire brands of No. 3 foundry iron, for delivery to users in the Lancashire price zone, are all quoted on the basis of 83s. per ton, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s., according to the class of consumer. There is a fair inquiry for Scottish foundry iron and West Coast hematite, the former at 91s. 6d., delivered equal to Manchester, and the latter at 93s. 6d., with East Coast hematite at 93s., both delivered in the Manchester district and subject to rebate.

MIDLANDS.—The light-castings makers remain the heaviest buyers of pig-iron, and many users have contracts extending up to the end of March. Engineers have recently had improved requirements, but they are having some difficulty in procuring all their needs owing to the fact that many producers have their outputs fully sold over several months, and thus are out of the market. Quotations of ordinary No. 3 foundry iron remain at 77s. 6d. for Northants, and 80s. for Derbyshire, Lincolnshire and North Staffordshire, delivered to Birmingham and Black Country stations, and subject to a small sliding-scale rebate to heavy users. Forge iron is still quoted at 5s. per ton below No. 3 foundry if used for puddling, and 3s. per ton less if required for foundry purposes. The demand is on a good scale. Large tonnages of special irons are being regularly taken up by engineering and jobbing concerns, and prices, which remain without control, vary considerably, according to analysis and transport charges, and are as follow:—Medium-phosphorus iron, 82s. 6d., minimum, to 90s.; low-phosphorus, including Scottish brands, 92s. 6d. to 100s.; refined pig-iron, £6 10s. to £8 10s. per ton, delivered. Firm conditions continue to rule on the hematite market, and supplies of some grades of West Coast material are very difficult to obtain. Values are unaltered, with East Coast No. 3 at £4 16s., West Coast mixed numbers at £4 17s., and Welsh mixed numbers at £4 15s. 6d., delivered Midland stations, with 1s. 6d. per ton extra if delivered to works.

SCOTLAND.—There is only a small amount of new business being transacted in this area, as the majority of consumers are well covered. Makers, also, are unwilling to increase their commitments owing to the fact that costs of production are rising steadily. Official minimum values remain at 81s. 6d. for No. 1 and 79s. for No. 3 foundry f.o.t. furnaces. Prices of Cleveland No. 3 iron are 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow. Supplies are scarce. The demands of the steelworks for supplies of basic and hematite are very heavy, but they are only able to buy up to the end of the year. Prices of steel-making irons remain unchanged, with mixed numbers of East Coast, West Coast and Scottish hematite at 85s. 6d., less 5s. rebate; and basic, British and Indian, 75s., less 5s. rebate, all delivered steelworks here.

Coke

There is little change to report in the condition of the foundry-coke market, which remains very firm. For delivery in Birmingham and district, current prices, which are likely to be raised, are 40s. to 42s. 6d. per ton for best Durham coke, with Welsh at 40s. to 50s. per ton.

Steel

The general tendency in most departments of the steel trade is for the demand to broaden, and the producers seem more concerned with limiting their commitments to the capacity of their works than with seeking new business, says the official report of the London Iron and Steel Exchange. Similarly stringent conditions exist in the semi-finished steel section of the market, and while the capacity of the British works is being strained to meet the demand, consumers are finding it difficult to obtain all the material they require. The demand for finished steel is absorbing the whole production and the periods asked for the execution of orders are being lengthened in several departments. The home demand continues to take so much of the output that only a small surplus is available for export.

Scrap

Heavy melting steel is well inquired for in the Cleveland area at 57s. 6d., and up to 60s. is frequently paid, while there is a good demand for machinery cast-iron scrap at 67s. 6d. Heavy foundry cast iron remains at 65s., with clean light cast iron at the reduced figure of 53s. per ton, delivered consumers' works. The Midland market continues to be firm, with a good demand experienced for all descriptions of scrap. Heavy steel in furnace sizes is at 52s. 6d. and mixed iron and steel at 51s. 6d. Heavy unsheared wrought iron is at 65s., with heavy machinery in cupola sizes at 70s., good heavy at 65s., and clean light metal 52s. 6d. to 55s. Short, heavy steel, as used in the foundries, is at 65s. per ton, delivered works. Satisfactory conditions are reported on the Scottish market, where there is a good demand. Heavy steel scrap is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 5s. less. Heavy machinery cast iron is 69s., with good, clean, ordinary cast iron, in pieces not exceeding 1 cwt., at 64s. to 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—Some heavy buying has been seen in this market during the past week, chiefly for early delivery, and the prices of spot and three months' metal reached the highest levels of the year. Armament firms continue to take up large tonnages. In the United States, a satisfactory business has been recorded. The strike at a refinery in Belgium has had the effect of strengthening the market.

Daily market prices:—

Cash.—Thursday, £39 to £39 1s. 3d.; Friday, £39 7s. 6d. to £39 8s. 9d.; Monday, £39 7s. 6d. to £39 8s. 9d.; Tuesday, £39 10s. to £39 11s. 3d.; Wednesday, £39 2s. 6d. to £39 3s. 9d.

Three Months.—Thursday, £39 3s. 9d. to £39 5s.; Friday, £39 10s. to £39 11s. 3d.; Monday, £39 11s. 3d. to £39 12s. 6d.; Tuesday, £39 12s. 6d. to £39 13s. 9d.; Wednesday, £39 5s. to £39 6s. 3d.

Tin.—At their meeting in London last week the International Tin Committee decided to retain for the ensuing quarter the production quota of 90 per cent. The question of the renewal of the control agreement also came under review, and the Siamese delegation stated their case. It was announced that the negotiations for renewal will continue. The next meeting of the Committee will be held at The Hague not later than October 23. Since the meeting the market has displayed a firmer tone, and the price of spot metal passed the £200 mark on Monday. World tinplate prospects are good. According to the statistical bulletin issued by the International Tin Research and Development Council, world apparent consumption of tin during the twelve months ended July 31 was 152,168 tons, compared with 129,101 tons in the preceding twelve months. World production is given as 162,183 tons, against 121,366 tons, for the same periods, while consumption in July was 13,832 tons, compared with 12,328 tons in June and 12,092 tons a year ago.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £196 to £196 5s.; Friday, £198 10s. to £198 15s.; Monday, £200 to £200 10s.; Tuesday, £200 10s. to £201; Wednesday, £203 10s. to £204.

Three Months.—Thursday, £193 15s. to £194; Friday, £196 10s. to £196 15s.; Monday, £197 17s. 6d. to £198; Tuesday, £197 15s. to £198; Wednesday, £200 to £200 5s.

Spelter.—Rather quiet conditions have prevailed on this market, but consumption is steadily maintained. Brass and oxide makers have taken up some good tonnages, while some expansion has been noticeable in the requirements of the galvanisers. There is nothing to report in connection with the efforts to re-establish the Zinc Cartel.

Official quotations were as follow:—

Ordinary.—Thursday, £13 16s. 3d.; Friday, £13 17s. 6d.; Monday, £14; Tuesday, £13 17s. 6d.; Wednesday, £13 13s. 9d.

Lead.—Buying has been very heavy for some time past, but a decline was experienced this week and market prices decreased slightly as a result. However, the set-back is only likely to be of a temporary nature and the outlook is quite satisfactory. Figures issued by the American Bureau of Metal Statistics show that stocks of refined lead in the United States at the end of August totalled 218,200 tons, compared with 231,100 tons at the end of July. Production last month totalled 33,500 tons, against 39,600 tons.

Day-to-day quotations:—

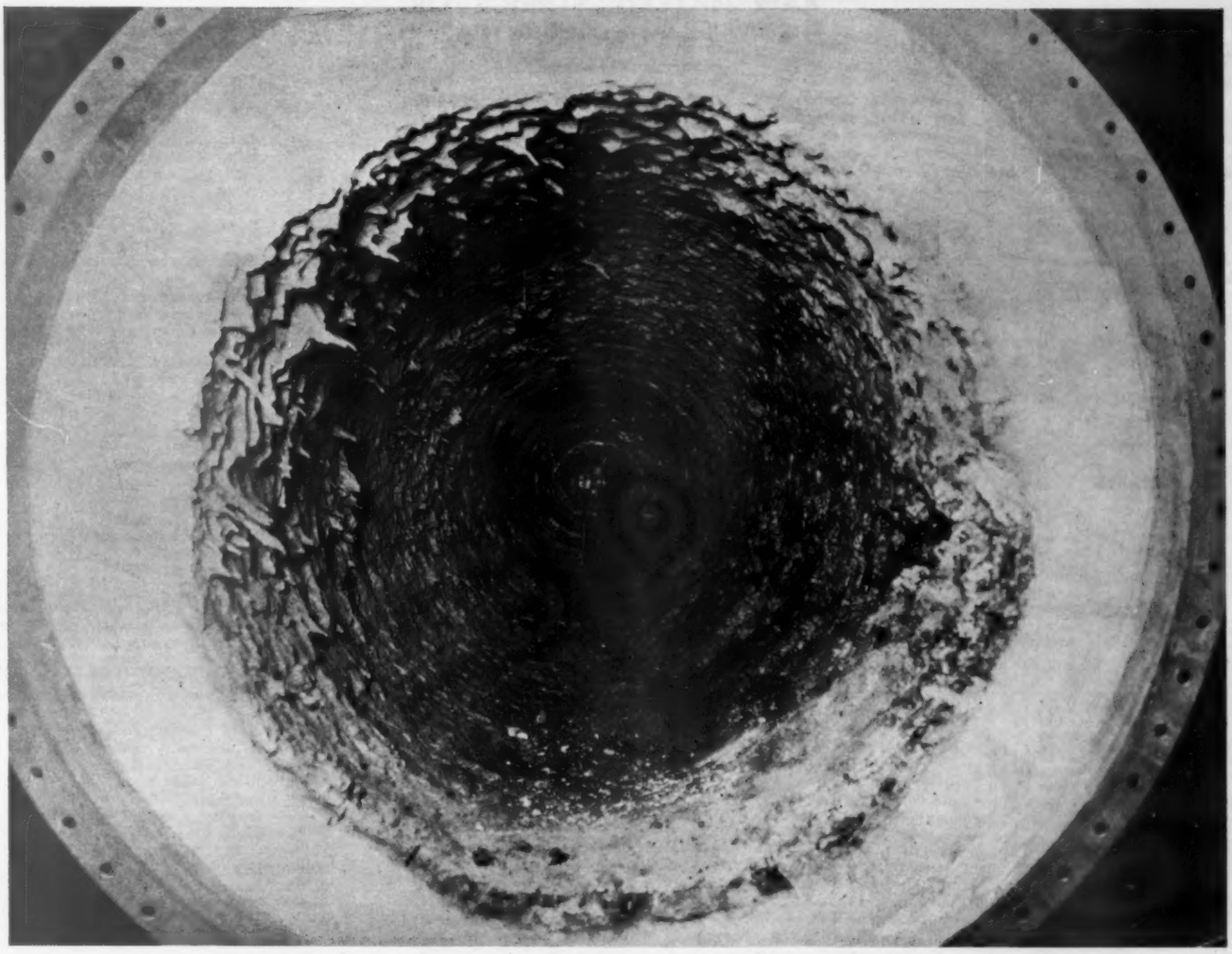
Soft Foreign (Prompt).—Thursday, £17 18s. 9d.; Friday, £17 17s 6d.; Monday, £18; Tuesday, £18 2s. 6d.; Wednesday, £18.

Refractory Roof Materials for Electric Furnaces

Report No. 316 of the Steelworks Committee of the Verein deutscher Eisenhüttenleute, by H. KRAL, published in "Stahl und Eisen," deals with further experimental work on the suitability of various special refractories for electric furnace roofs. The materials tested were magnesidon, "Bikorit" (an almost pure corundum), "Dioxil" (a pure quartz), "Alusil" (a corundum containing 83-85 per cent. Al_2O_3 and under 1 per cent. Fe_2O_3), "Chromodur" (a chrome ore), and "Magnosil" (a mineral found in Norway). In every case the material was not comparable to silica brick; some materials were not very durable, while others crumbled and introduced impurities in the steel bath. The cost of these substitutes is also higher than for silica, which precludes their practical use. The search for an economic refractory for electric-furnace roofs containing basic charges must therefore continue, concludes the author.

Education of Youths

The Education of Youths Committee of the Workington Branch of the United Steel Companies, Limited, has issued a poster outlining its arrangements for the education of youths at the Cumberland branches of the company. Arrangements for further education in evening classes have been made for the coming session, as well as for shift classes, technical courses, foreign-language courses, welding classes, free lectures and juvenile meetings. The employment of youths by the company is being made contingent on a satisfactory level of education and certification, the company's basic policy being to raise the educational standard of juvenile recruits.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, September 30, 1936)

COPPER

	£ s. d.
Standard cash	39 2 6
Three months	39 5 0
Electrolytic	43 15 0
Tough	42 10 0
Best selected	43 0 0
Sheets	72 0 0
India	53 5 0
Wire bars	44 10 0
Ingot bars	44 10 0
H.C. wire rods	48 0 0
Off. av. cash, Aug.	38 5 11½
Do., 3 mths., Aug.	38 11 3⅜
Do., Sttlmnt., Aug.	38 5 9
Do., Electro, Aug.	42 13 0
Do., B.S., Aug.	42 5 0
Do., wire bars, Aug.	42 18 6
Solid drawn tubes	11d.
Brazed tubes	11d.
Wire	6½d.

BRASS

Solid drawn tubes	10d.
Brazed tubes	12d.
Rods, drawn	9d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8½d.
Wire	8d.
Rolled metal	7⅞d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£ s. d.
Standard cash	203 10 0
Three months	200 0 0
English	203 10 0
Bars	205 10 0
Straits	206 0 0
Australian	203 10 0
Eastern	206 10 0
Banca (nom.)	205 10 0
Off. av. cash, Aug.	183 17 7½
Do., 3 mths., Aug.	180 17 1½
Do., Sttlmt., Aug.	183 17 0

SPELTER

	£ s. d.
Ordinary	13 13 9
Remelted	13 10 0
Hard	11 15 0
Electro 99.9	15 13 9
English	14 15 0
India	12 15 0
Zinc dust	19 15 0
Zinc ashes	4 10 0
Off. aver., Aug.	13 12 10½
Aver. spot, Aug.	13 10 6¾

LEAD

	£ s. d.
Soft foreign ppt.	18 0 0
Empire	18 17 6
English	20 0 0
Off. average, Aug.	16 16 3¾
Average spot, Aug.	16 15 5¼

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	24 0 0 to 24 10 0
Do., V.M. ex-whse.	24 0 0 to 24 10 0
Rods	26 0 0

ANTIMONY

English	64 10 0 to 66 0 0
Chinese, ex-whse.	56 0 0
Crude, c.i.f.	25 0 0

QUICKSILVER

Quicksilver	13 5 0 to 13 5 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	11 10 0 to 12 15 0
75%	16 12 6 to 17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1½ lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.50% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	£10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ⅛ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel		3 4 0
Mixed iron and steel	2 19 0	to 3 0 0
Heavy cast iron	2 18 0	to 3 0 0
Good machinery	3 2 0	to 3 4 0
Cleveland—		
Heavy steel	2 17 6	to 3 0 0
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap	2 12 6	to 2 15 0
Heavy wrought iron		3 5 0
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron	3 4 0	to 3 5 0
Engineers' turnings		2 2 6
Cast-iron borings		1 18 0
Wrot-iron piling	3 9 0	to 3 10 0
Heavy machinery		3 9 0

London—Merchants' buying prices, delivered yard.

Copper (clean)	32 0 0
Brass	20 0 0
Lead (less usual draft)	16 10 0
Tea lead	12 0 0
Zinc	8 10 0
New aluminium cuttings	74 0 0
Braziery copper	29 0 0
Gunmetal	30 0 0
Hollow pewter	142 0 0
Shaped black pewter	107 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/–
,, No. 4	74/–
Forge No. 4	74/–
Hematite No. 1	85/6*
Hematite M/Nos.	85/–*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/–*
Malleable iron d/d Birm.	125/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/–
,, No. 3 fdry.	80/–
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/–
,, fdry. No. 3	80/–
,, fdry. No. 1	83/–
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/–
Cleveland No. 3, Glasgow	78/–
,, ,, Falkirk	75/–
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/–*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/–
Staffs fdry. No. 3	83/–
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	91/6
Clyde, No. 3	91/6
Monkland, No. 3	91/6
Summerlee, No. 3	91/6
Eglinton, No. 3	91/6
Gartsherrie, No. 3	91/6
Shotts, No. 3	91/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

	£ s. d.	£ s. d.
Iron—		
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6	to 9 7 6
Hoops	11 7 6	and up.
Marked bars (Staffs) f.o.t.		13 0 0
Gas strip	11 7 6	and up.
Bolts and nuts, ¾ in. × 4 in.	16 0 0	and up.
Steel—		
Plates, ship, etc.	9 7 6	to 9 10 0
Boiler plts.	9 17 6	to 10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5½ in.		10 0 0
Rounds under 3 in. to ⅜ in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. (,,)		14 0 0
Galv. flat shts. (,,)		14 10 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 2 6	to 7 7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	12d.
Tubes	14d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3
Ingots rolled to spoon size	10d. to 1/6
Wire round—	
to 10g.	1/4½ to 1/11

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	1.90
Plain wire	2.40
Barbed wire, galv.	2.40
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/– to 32/6
,, furnace	24/6 to 25/–
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/–
,, furnace	25/– to 26/–

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	18/9
,, 28×20 ,,	37/6
,, 20×10 ,,	26/9 to 27/–
,, 18¾×14 ,,	19/6
C.W. 20×14 ,,	15/6 to 15/9
,, 28×20 ,,	33/9 to 34/–
,, 20×10 ,,	22/6 to 22/9
,, 18⅜×14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£25 0 0 to £28 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Sept. 24 ..	39 0 0 inc.	5/-
„ 25 ..	39 7 6 „	7/6
„ 28 ..	39 7 6 No	change
„ 29 ..	39 10 0 inc.	2/6
„ 30 ..	39 2 6 dec.	7/6

Electrolytic Copper

	£ s. d.	
Sept. 24 ..	43 5 0 inc.	2/6
„ 25 ..	43 10 0 „	5/-
„ 28 ..	44 0 0 „	10/-
„ 29 ..	44 0 0 No	change
„ 30 ..	43 15 0 dec.	5/-

Standard Tin (cash)

	£ s. d.		
Sept. 24 ..	196 0 0 inc.	75/-	
„ 25 ..	198 10 0 „	50/-	
„ 28 ..	200 0 0 „	30/-	
„ 29 ..	200 10 0 „	10/-	
„ 30 ..	203 10 0 „	60/-	

Tin (English ingots)

	£ s. d.		
Sept. 24 ..	196 0 0 inc.	70/-	
„ 25 ..	198 10 0 „	50/-	
„ 28 ..	200 0 0 „	30/-	
„ 29 ..	200 10 0 „	10/-	
„ 30 ..	203 10 0 „	60/-	

Spelter (ordinary)

	£ s. d.		
Sept. 24 ..	13 16 3 dec.	1/3	
„ 25 ..	13 17 6 inc.	1/3	
„ 28 ..	14 0 0 „	2/6	
„ 29 ..	13 17 6 dec.	2/6	
„ 30 ..	13 13 9 „	3/9	

Spelter (Electro, 99.9 per cent.)

	£ s. d.		
Sept. 24 ..	15 16 3 dec.	1/3	
„ 25 ..	15 17 6 inc.	1/3	
„ 28 ..	16 0 0 „	2/6	
„ 29 ..	15 17 6 dec.	2/6	
„ 30 ..	15 13 9 „	3/9	

Lead (soft foreign, prompt)

	£ s. d.		
Sept. 24 ..	17 18 9 dec.	1/3	
„ 25 ..	17 17 6 „	1/3	
„ 28 ..	18 0 0 inc.	2/6	
„ 29 ..	18 2 6 „	2/6	
„ 30 ..	18 0 0 dec.	2/6	

Lead (English)

	£ s. d.		
Sept. 24 ..	20 0 0 No	change	
„ 25 ..	19 15 0 dec.	5/-	
„ 28 ..	20 0 0 inc.	5/-	
„ 29 ..	20 0 0 No	change	
„ 30 ..	20 0 0 „	„	

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1896	37 3	38 4	38 7	38 1	37 4	37 4	36 11	36 11	37 11	39 2	40 5	40 5	38 3
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 6	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	48 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	58 6	54 10	56 0	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 0½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	59 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 8	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	99 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	122 1½	121 11	97 1½	97 0	100 0	100 9	110 6½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	86 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	68 9	67 6	67 6	66 10½	65 0	73 3½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	72 6	72 6	72 6	72 6	72 6	70 4½
1930	72 6	72 6	70 0	67 6	67 6	67 6	67 6	64 6	63 6	63 6	63 6	63 6	68 11½
1931	59 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 7
1932	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6
1933*	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6
1934*	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	66 10½
1935*	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	69 4½	70 0	67 10½
1936*	70 0	70 0	70 0	70 0	70 0	70 0	75 0	75 0	—	—	—	—	—

* Delivered Middlesbrough area. Prior to 1933, prices were f.o.t. furnaces.

WILLIAM JACKS & COMPANY,
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK
LUMPEX

FOR EVERY TYPE OF CASTING

NON-FERROUS METALS

REFRACTORIES — COKE — SAND
FERRO-SILICON—FERRO-CHROME

WILLIAM JACKS & COMPANY,
CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.
ZETLAND ROAD, MIDDLESBROUGH.

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

WANTED.—Position as Foreman or Assistant. Comprehensive practical experience, engineering; machine-moulding; modern methods. Technical knowledge. Keen and energetic.—Box 910, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Position as Foreman or Assistant. Experienced jobbing; repetition; high-duty and ordinary cast iron. Age 30. Guaranteed to get results.—Box 896, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FIRM of Manufacturers requires services of man with full technical knowledge of manufacture and practical application of metallic hardening and waterproofing compounds.—Apply Box 208, HESLOCK ADVERTISING AGENCY, 6, Gt. George Street, Leeds.

FOUNDRY Manager, about 35 years of age, used to jobbing work up to 15 tons weight, experienced with Sandslinger. State age, wage and experience.—Box 918, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

METALLURGIST required for large Engineering Works with steel, iron and bronze foundries. State full experience, age, and salary required.—Box 914, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

STEELFOUNDRY Foreman required to take charge of night shift. Must have good control of men. Apply giving age and full particulars of experience to: KRYN & LAHY (1928), LTD., Letchworth, Herts.

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